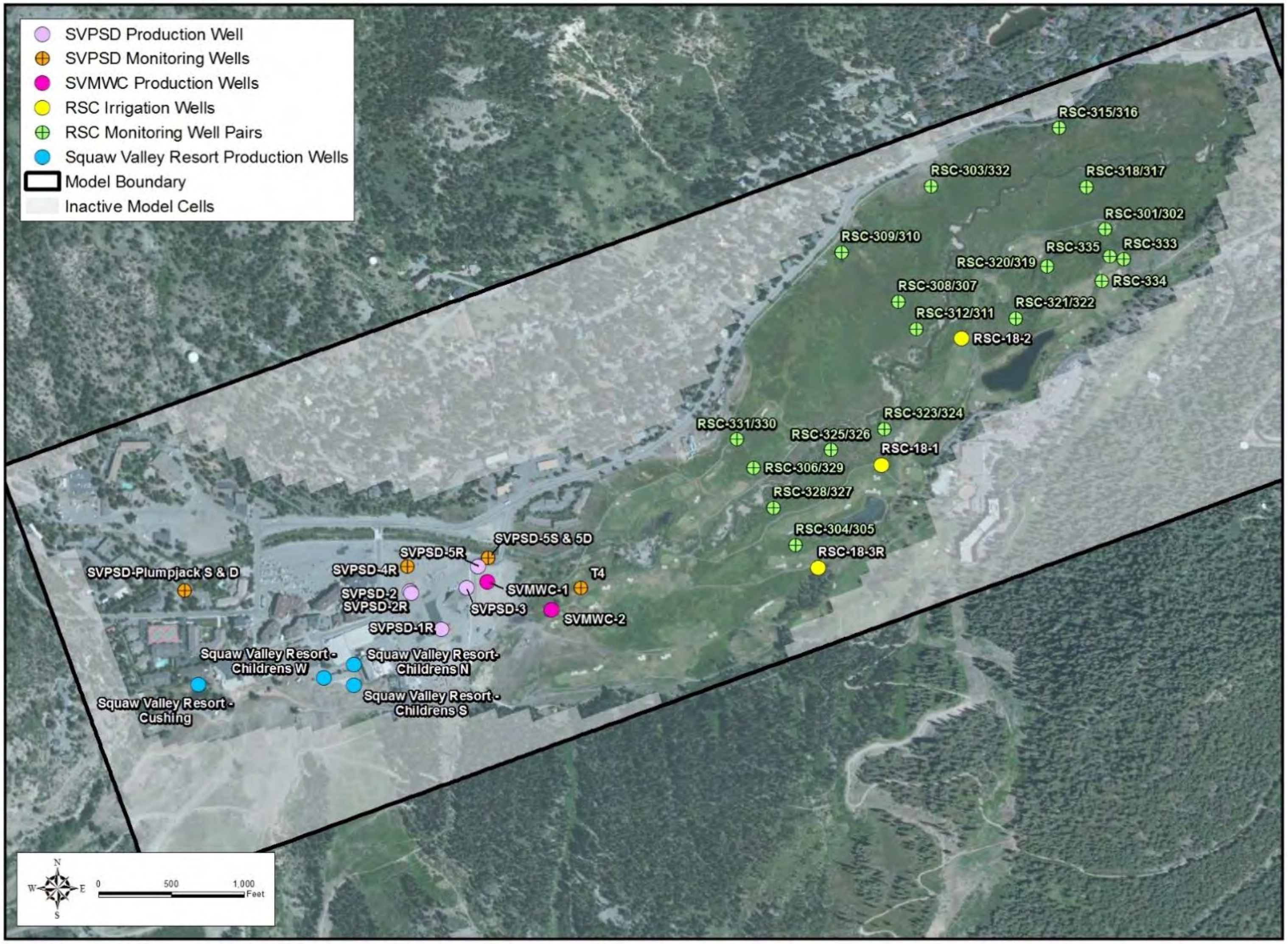


Figure 4: Target Well Locations

A complete set of hydrographs showing both observed and simulated groundwater elevations are included in Appendix A. These hydrographs show that the simulated groundwater elevations generally track measured groundwater elevations well, particularly between 2012 and 2014.

Various graphical and statistical methods can be used to demonstrate the magnitude and potential bias of the calibration errors. Figure 5 shows all simulated groundwater elevations plotted against observed groundwater elevations for the time period covering May 1992 through January 2015. Results from a unbiased model will scatter around a 45° line on this graph. Models that have a bias either overestimating or underestimating groundwater elevations will exhibit results that tend to cluster above or below this line, respectively.
Figure 5 demonstrates that the results tend to cluster slightly below the 45° line, with suggests a minor bias towards underestimating average groundwater levels. This is likely due to the fact that the model cannot simulate the measured groundwater elevations that are above ground surface in the meadow area, where the RSC observation wells are located. This bias is reflected on Figure 6, which plots model residuals along the range of observed groundwater elevations, and shows that a slightly denser distribution of residuals which fall below the "zero" line of residual values, relative to above that line.

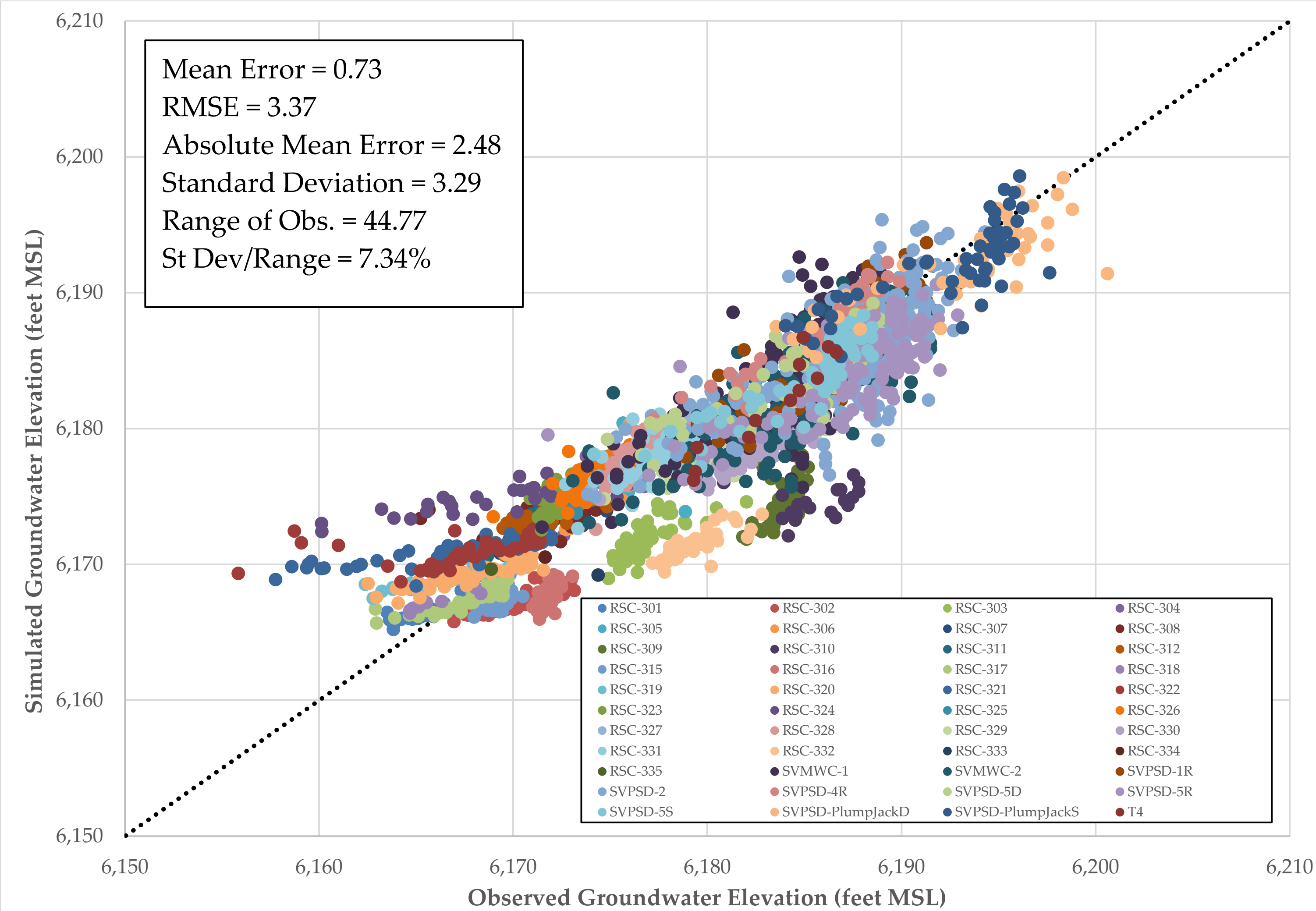


Figure 5: Simulated Versus Observed Groundwater Elevations

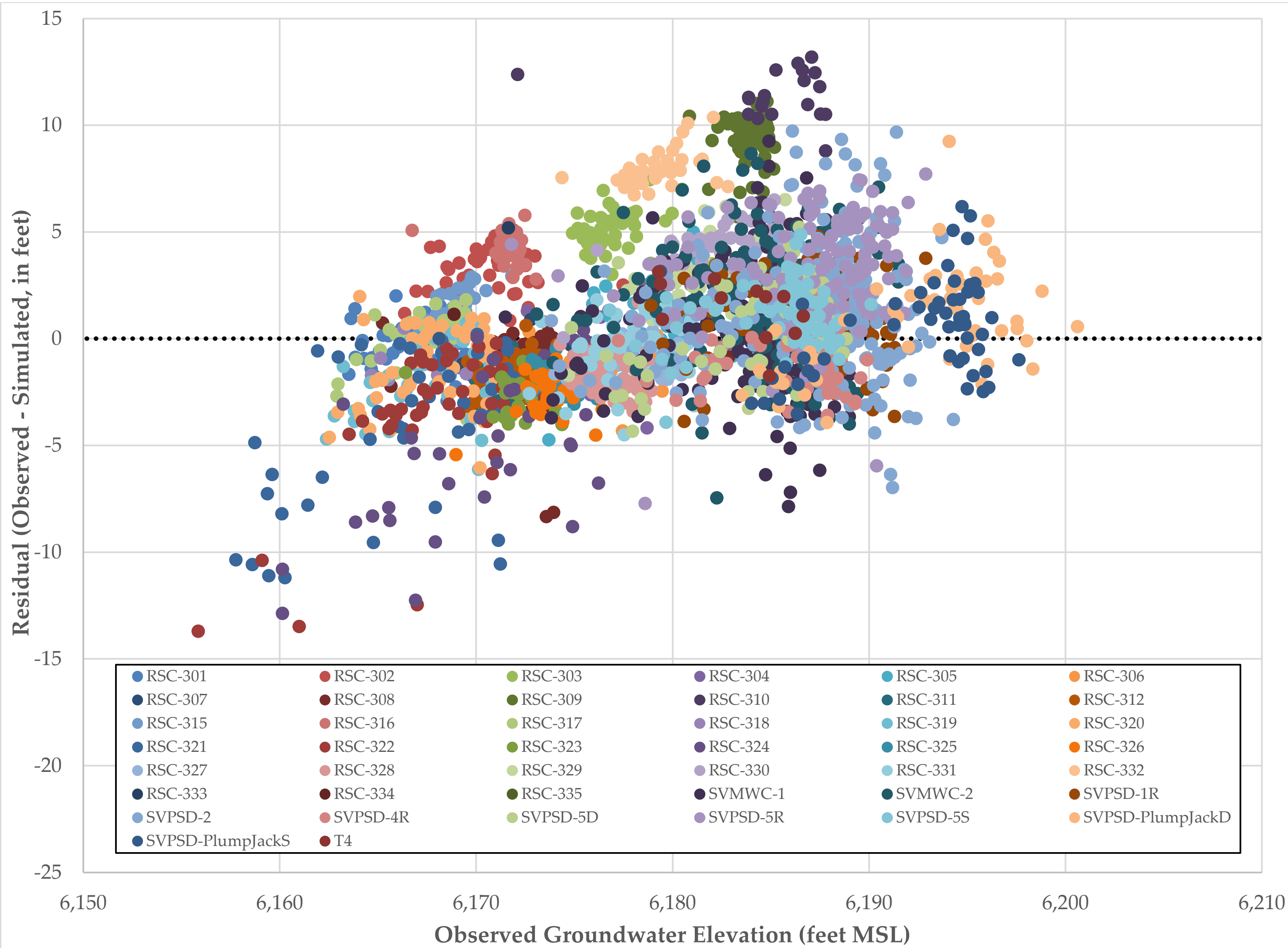


Figure 6: Observed Groundwater Elevations versus Model Residual

Figure 5 also includes various calibration statistics. The four statistical measures used to evaluate calibration are the mean error (ME), the mean absolute error (MAE), the standard deviation of the errors (STD), and the root mean squared error (RMSE). Each of these statistical measures was calculated using weighted measurements, where all weights have been normalized such that the sum of all weights is equal to one.

The ME is the average error between measured and simulated groundwater elevations for all data on Figure 5.

$$ME = \sum_{i=1}^{n} w_i \left(h_m - h_s\right)_i$$

Where h_m is the measured groundwater elevation, h_s is the simulated groundwater elevation, w_i is the normalized observation weight and n is the number of observations.

The MAE is the average of the absolute differences between measured and simulated groundwater elevations.

$$MAE = \sum_{i=1}^{n} w_i \left|h_m - h_s\right|_i$$

The STD of the errors is one measure of the spread of the errors around the 45º line on Figure 5. The population standard deviation is used for these calculations.

$$STD = \sqrt{\sum_{i=1}^{n} w_i \left(h_m - h_s\right)_i^2 - \left(\sum_{i=1}^{n} w_i \left(h_m - h_s\right)_i\right)^2}$$

The RMSE is similar to the STD of the error. It also measures the spread of the errors around the 45º line on Figure 5, and is calculated as the square root of the average squared errors.

$$RMSE = \sqrt{\sum_{i=1}^{n} w_i \left(h_m - h_s\right)_i^2}$$

As a measure of successful model calibration, the ratio of the spread of the errors to the total head range in the system should be small to ensure that the errors are only a small part of the overall model response. According to Anderson and Woessner (1992), the RMSE should be less than 10% of the total range of observed heads in the model. The RMSE of 3.37, as shown on Figure 5, is approximately 7.53% of the total head range of 44.77 feet. A second general rule that is occasionally used is that the mean error should be less than 5% of the total range of observed heads in the model. The mean error of 0.73 is approximately 1.6% of the total head range. Therefore, on average, these calibration statistics fall within the range of generally-accepted values for a well-calibrated model.

SECTION 4
Conclusions

The recent modeling update builds upon successive historical model improvement and calibration efforts, most recently those presented in June, 2014 (Hydrometrics WRI, 2014). The model's time domain was extended through January 2015; and groundwater pumping, recharge conditions, streamflows, and observed groundwater elevations were added to the model for this recent time period. All assumptions regarding boundary conditions, hydrostratigraphy, and material properties made in previous model documentation were retained in the updated model. The amount of precipitation entering the model domain as recharge was modified both to reflect our current understanding of the recharge dynamics of the Squaw Valley, as well as to improve simulated model fit to observed data, particularly for recent years. The fact that modifications to the model constrained to this relatively minor change to recharge inputs should reinforce the success of earlier calibration efforts in providing a robust platform for successive model updates and predictive simulations.

The updated and recalibrated groundwater model continues to accurately simulate groundwater levels in Squaw Valley reasonably well, and to within the generally-accepted range of calibration statistics for a well-calibrated model. The updated groundwater model continues to be an accurate and dependable tool for development of future groundwater pumping plans.

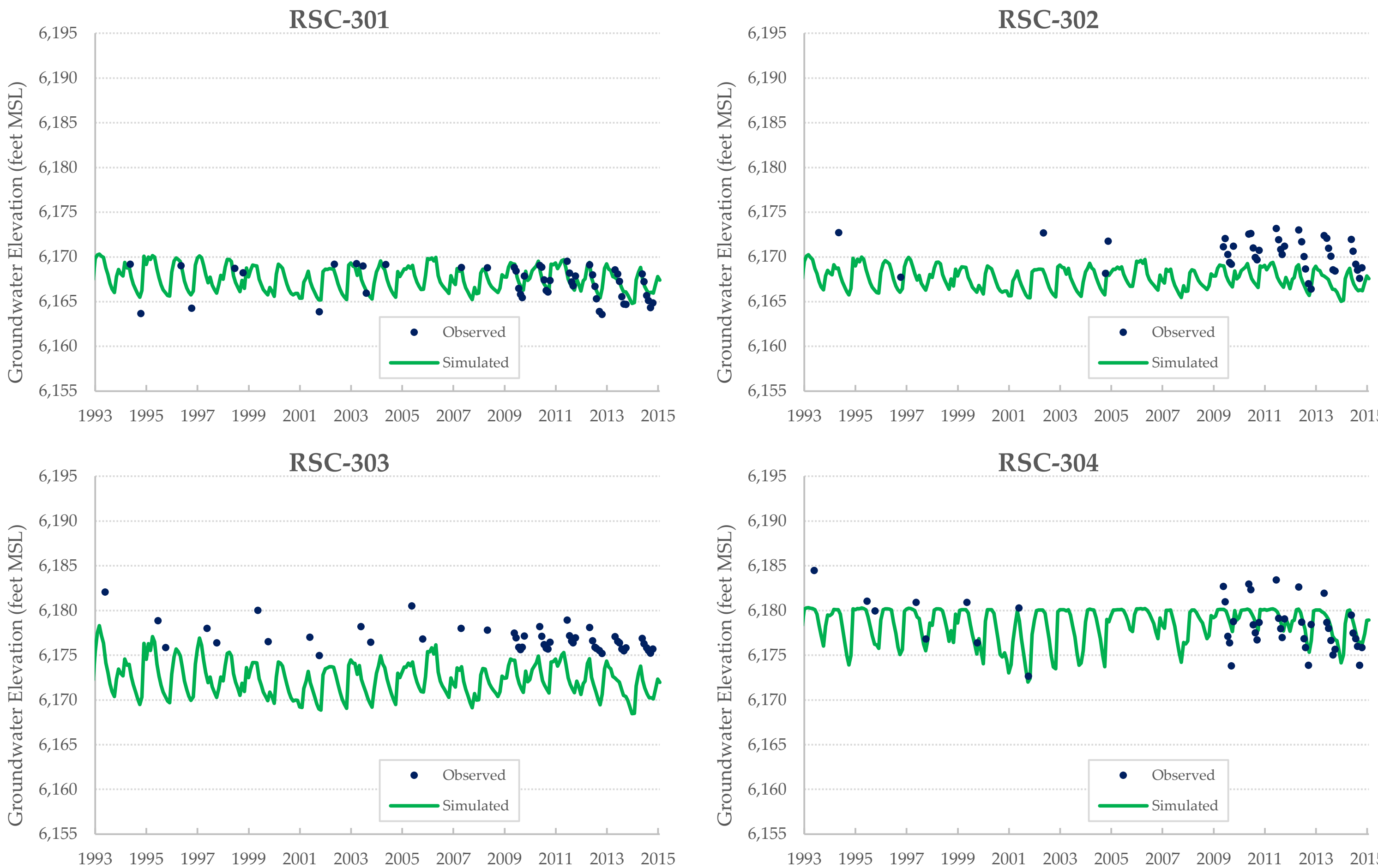
SECTION 5
References

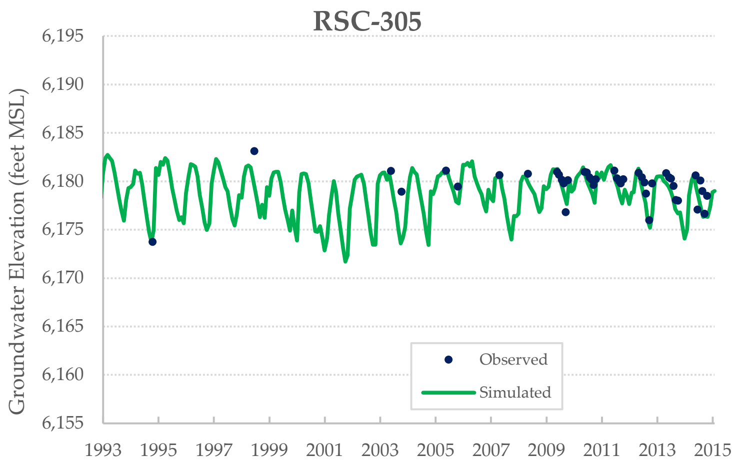
Anderson, M.P., and W.W. Woessner. 1992. *Applied groundwater modeling, simulation of flow and advective transport,* Academic Press, Inc., San Diego, California, 381 p.

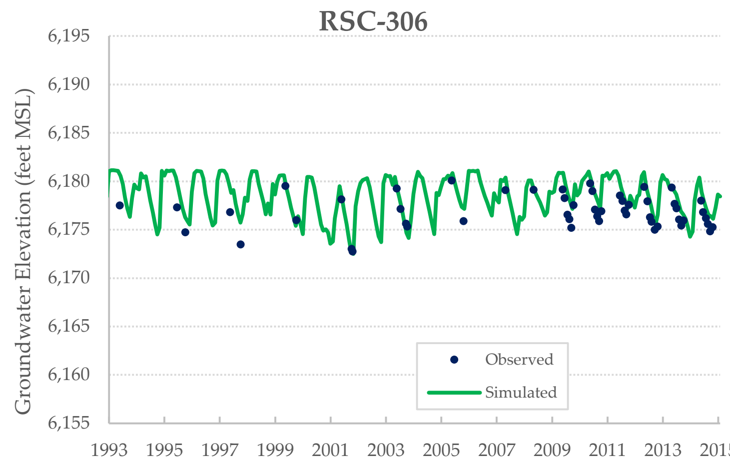
HydroMetrics WRI. 2013. *Squaw Valley creek/aquifer study model update report*, prepared for Squaw Valley Public Service District, November, 49 p.

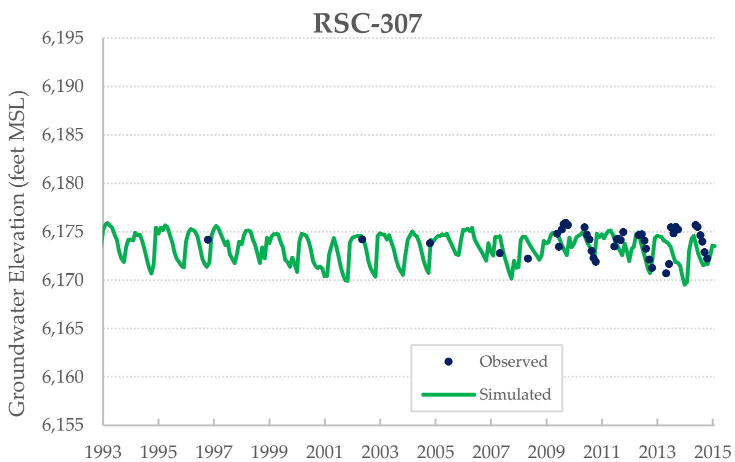
HydroMetrics WRI. 2014. *Technical memorandum, Squaw Valley Groundwater model 2014 Recalibration*, prepared for Squaw Valley Public Service District, June, 36 p.

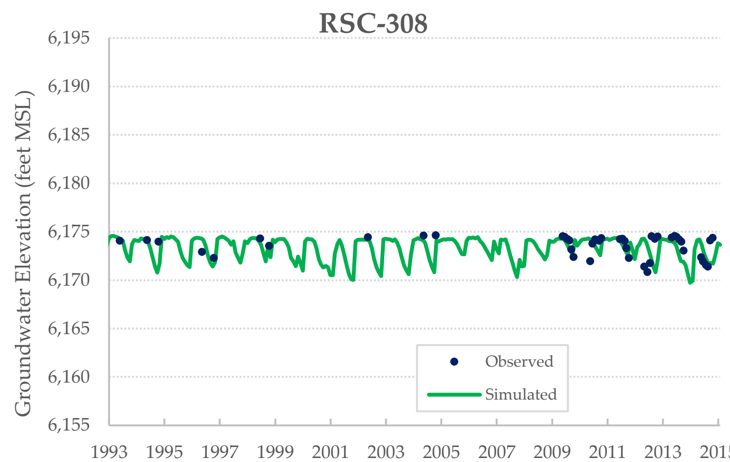
Appendix A: Measured and Simulated Hydrographs

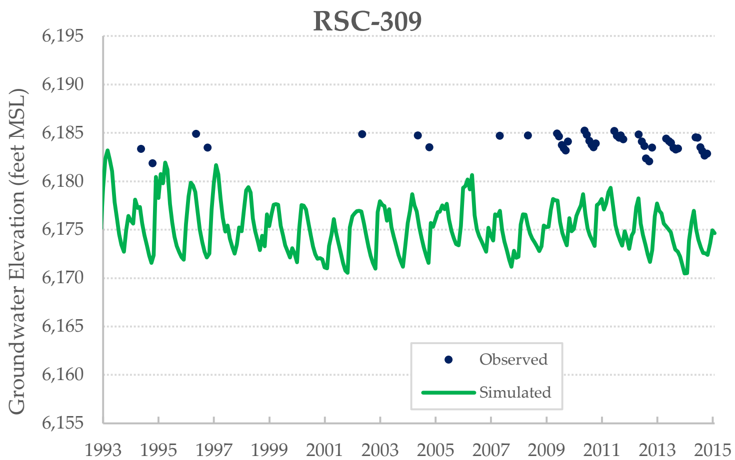

RSC-301
RSC-302
RSC-303
RSC-304
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

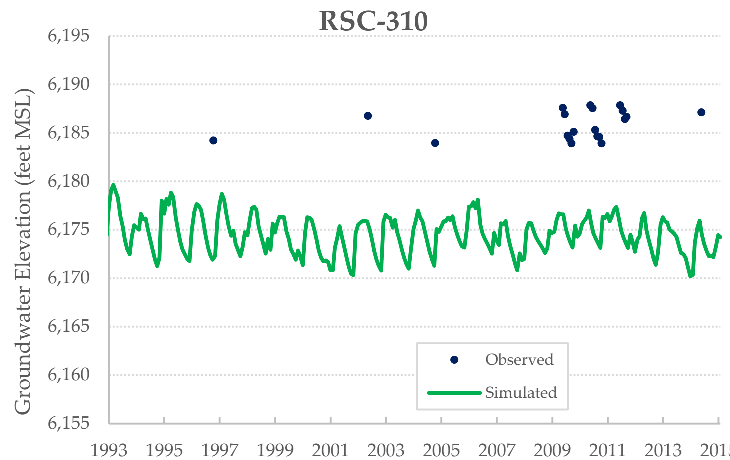

RSC-305
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated

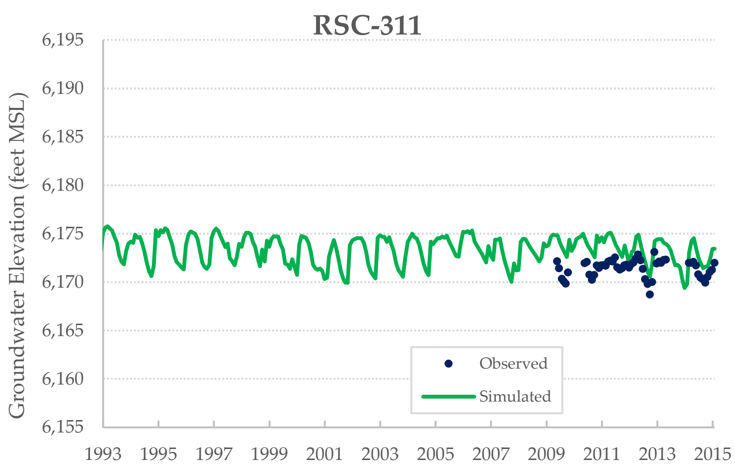

RSC-306
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated

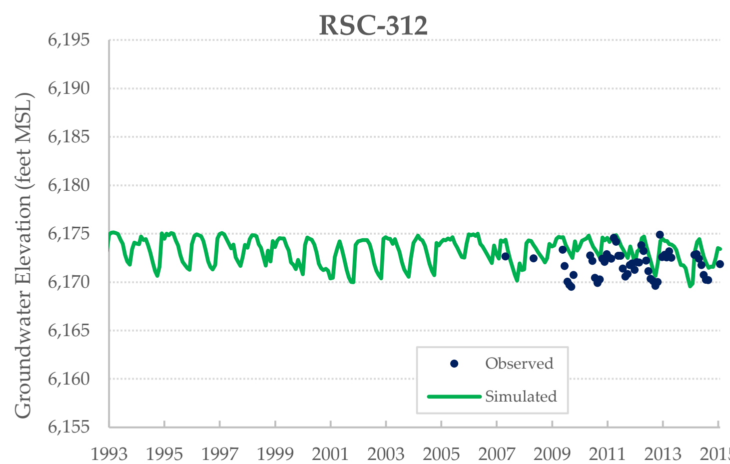

RSC-307
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated

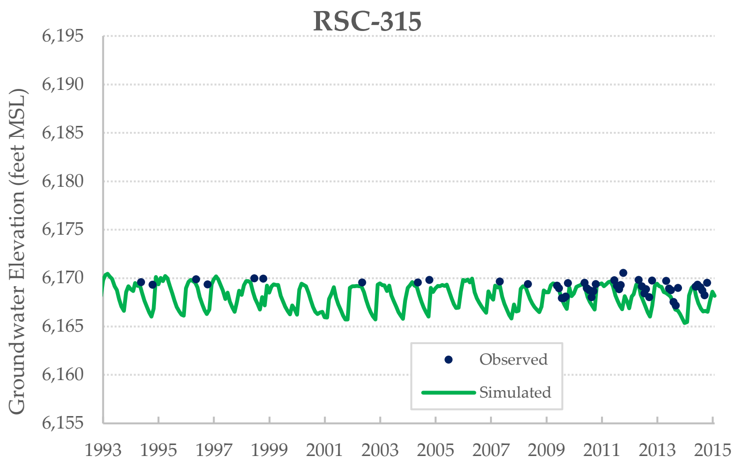

RSC-308
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated

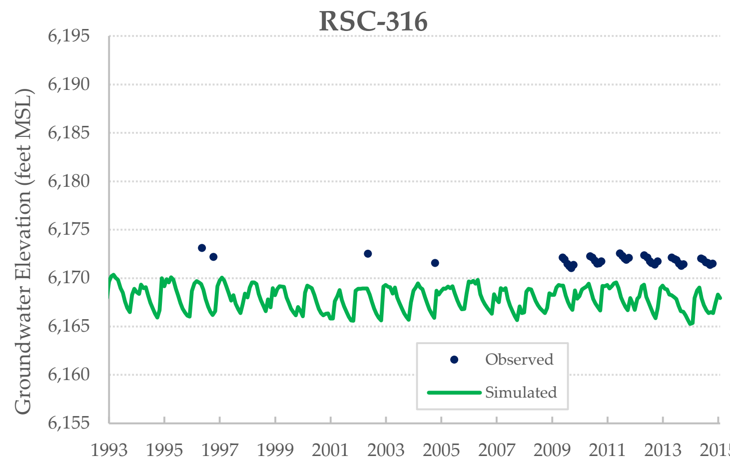

RSC-309
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

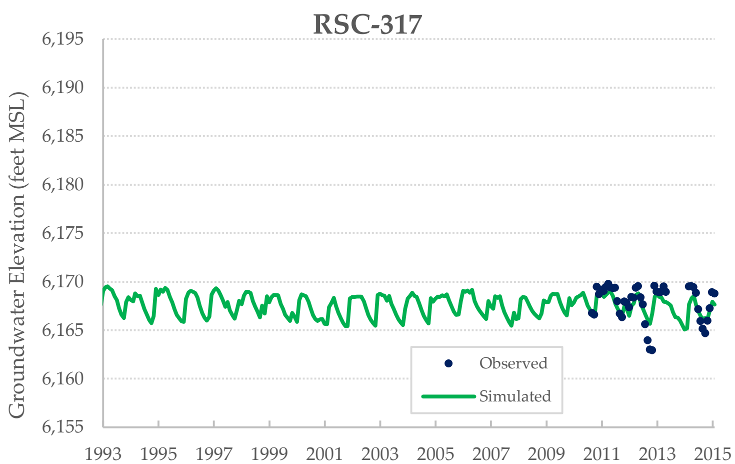

RSC-310
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

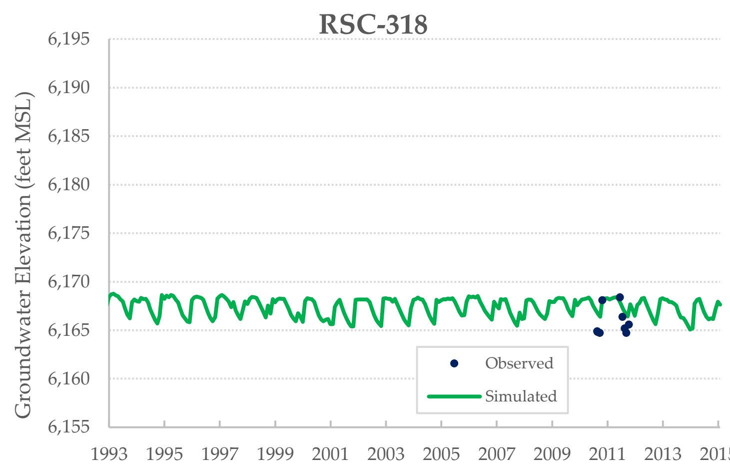

RSC-311
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

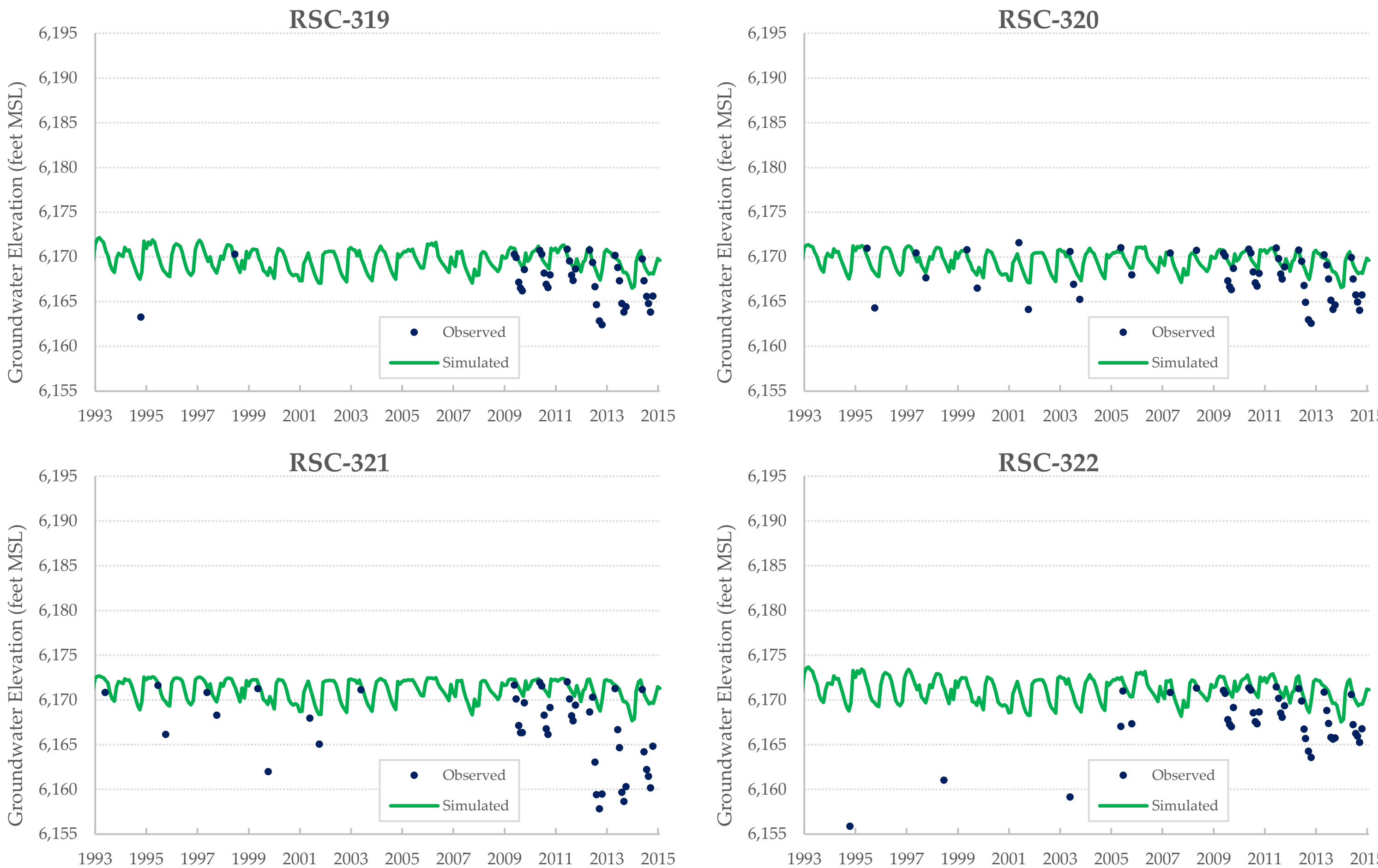

RSC-312
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

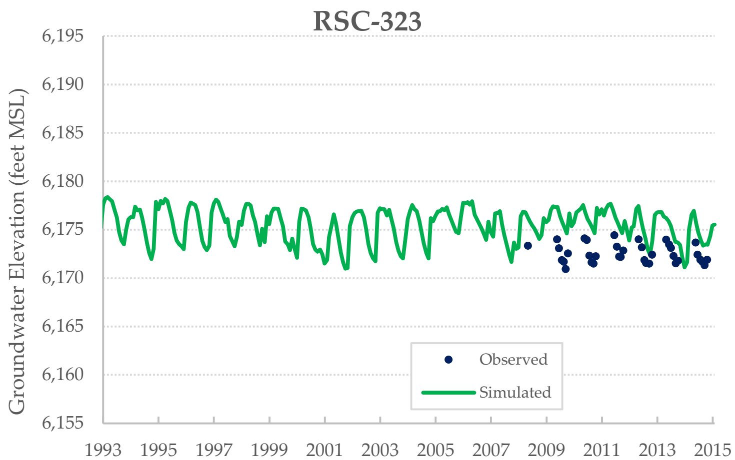

RSC-315
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

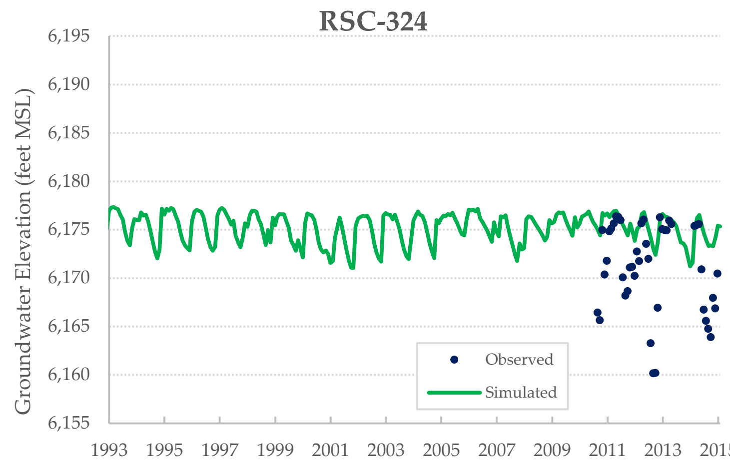

RSC-316
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

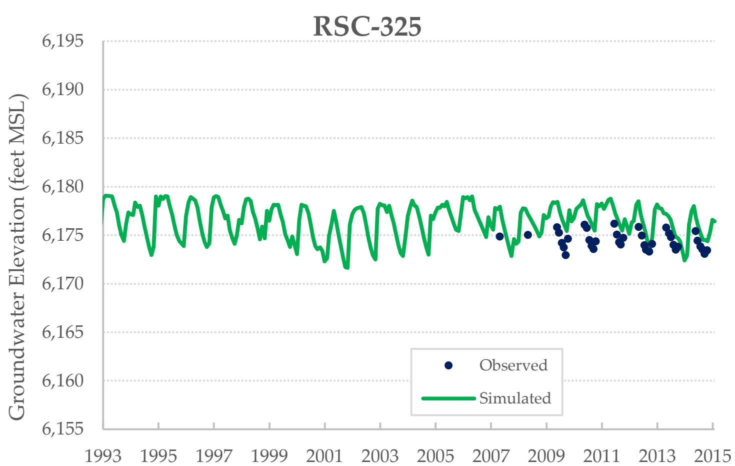

RSC-317
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

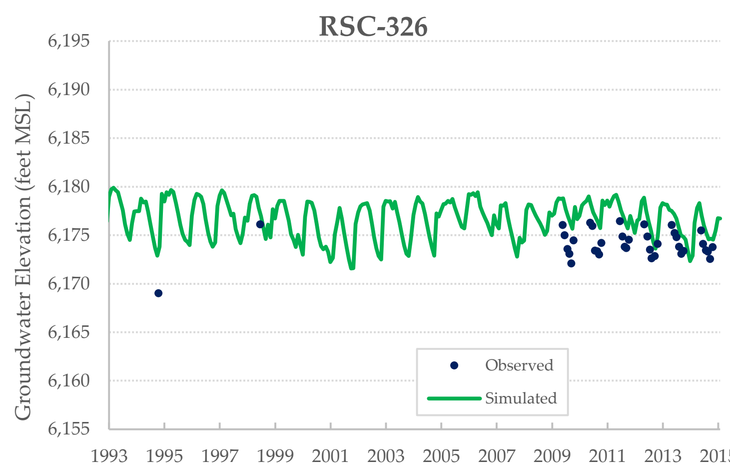

RSC-318
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

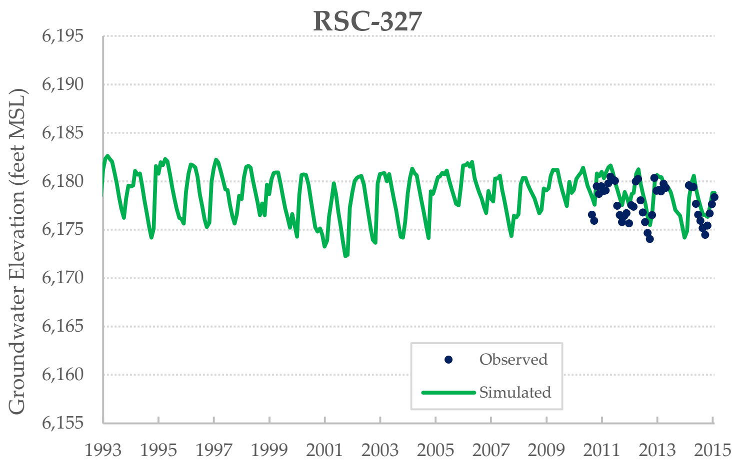

RSC-319
RSC-320
RSC-321
RSC-322
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated

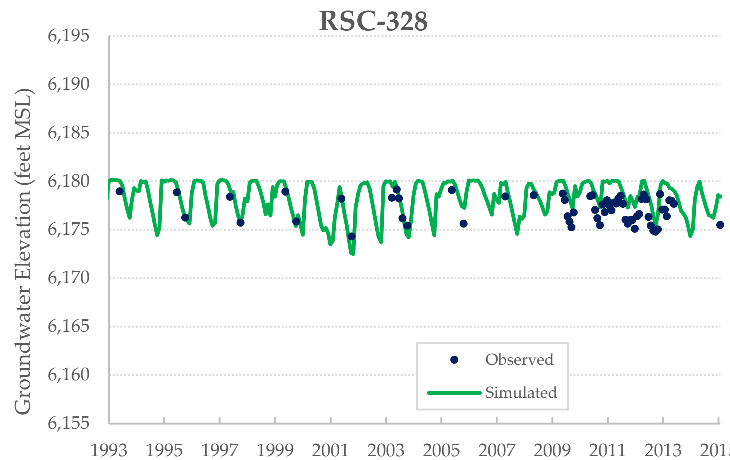

RSC-323
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

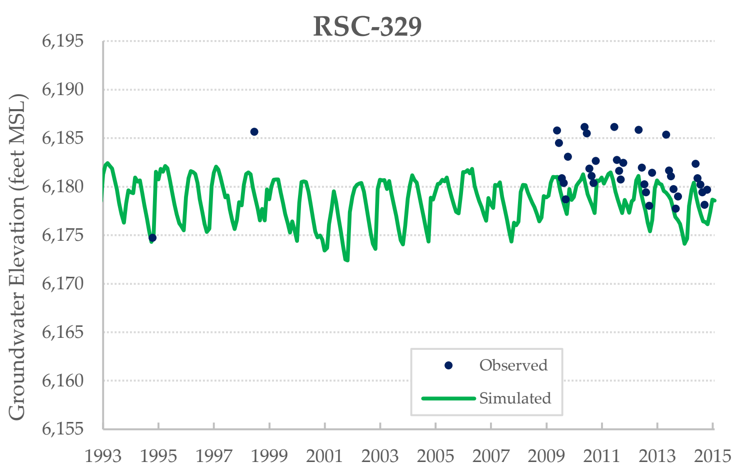

RSC-324
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

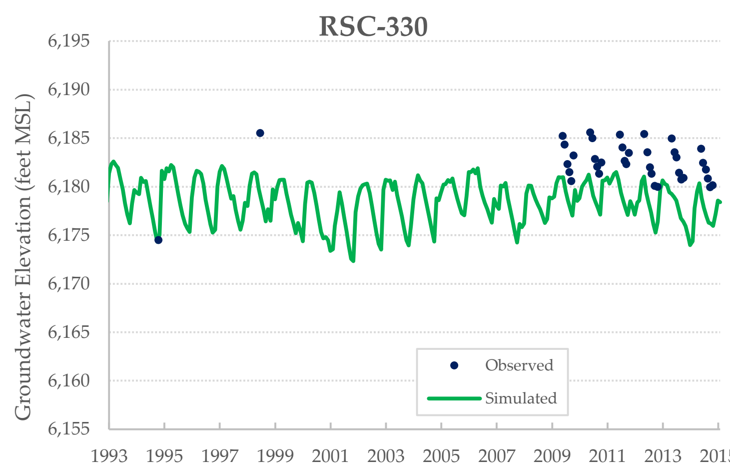

RSC-325
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

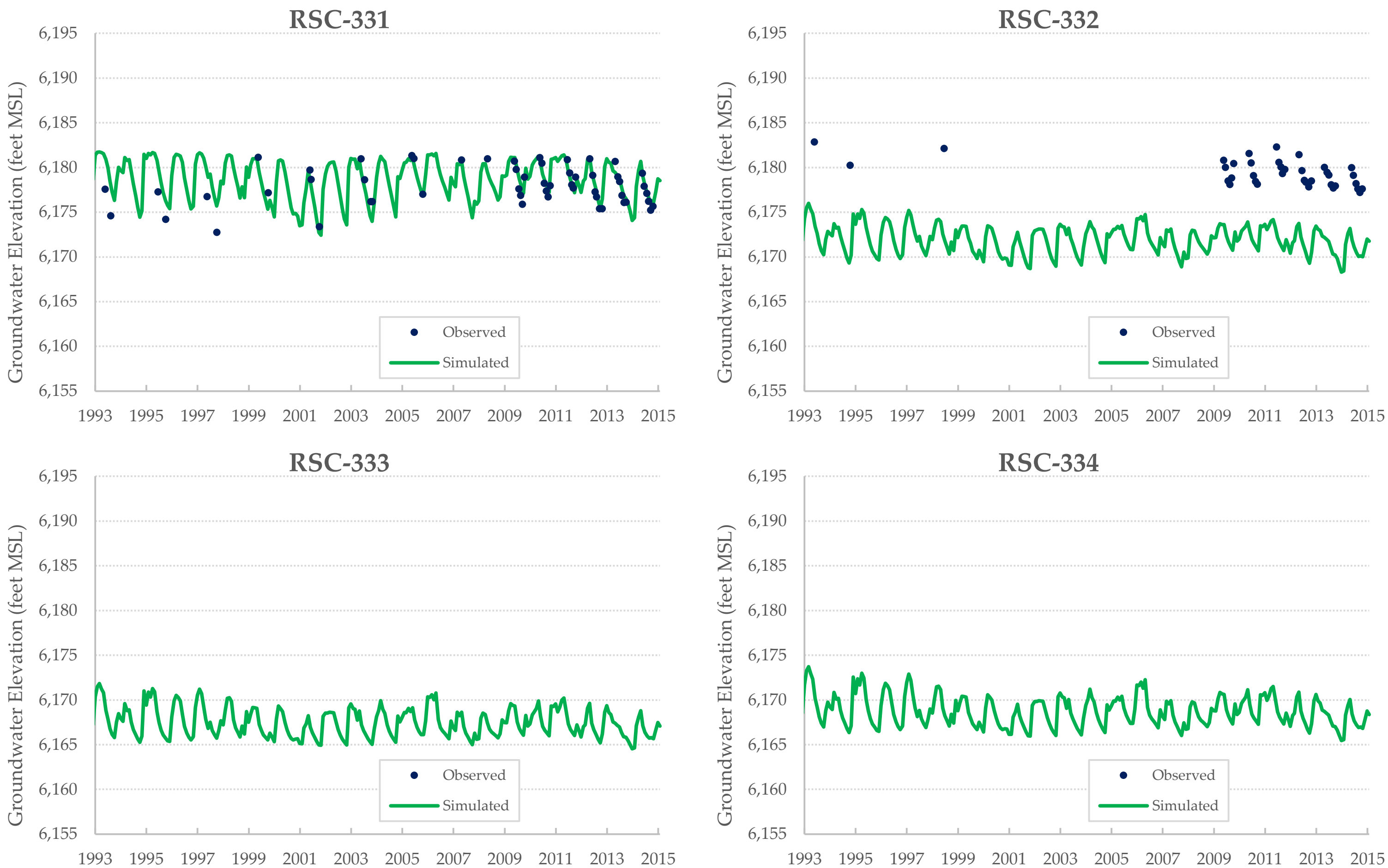

RSC-326
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

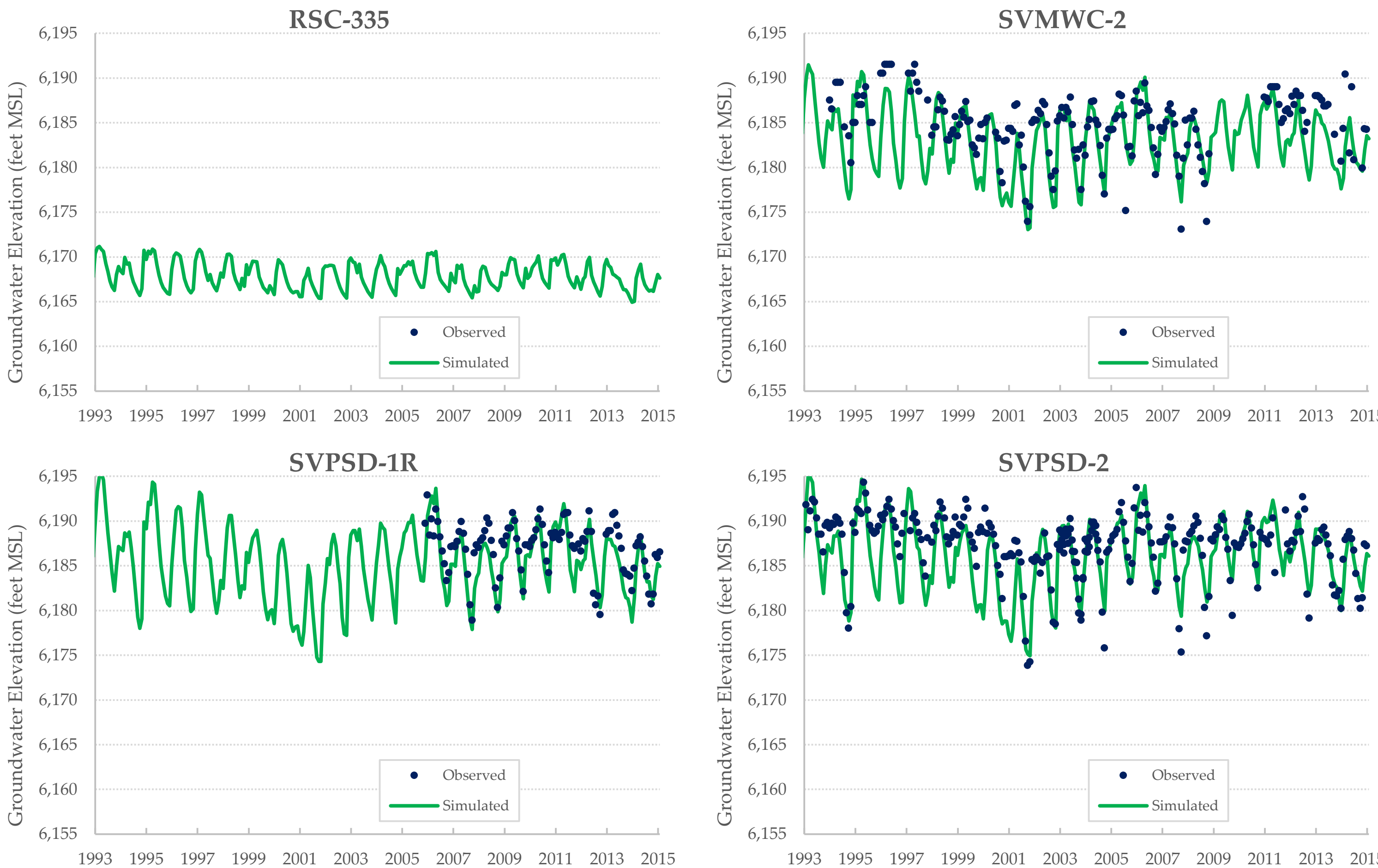

RSC-327
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated

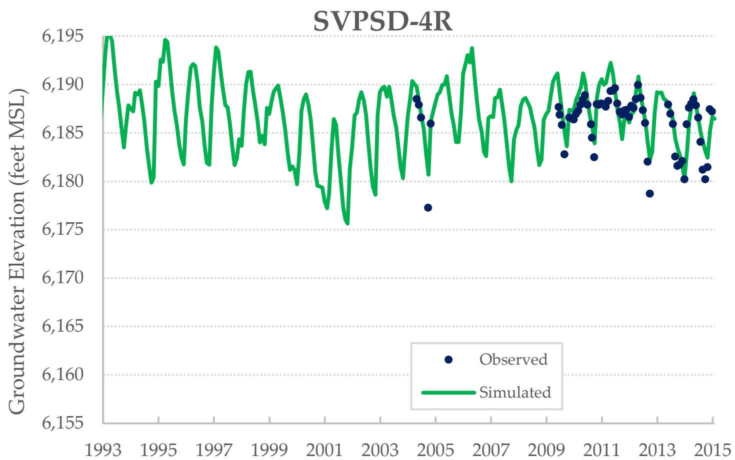

RSC-328
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated

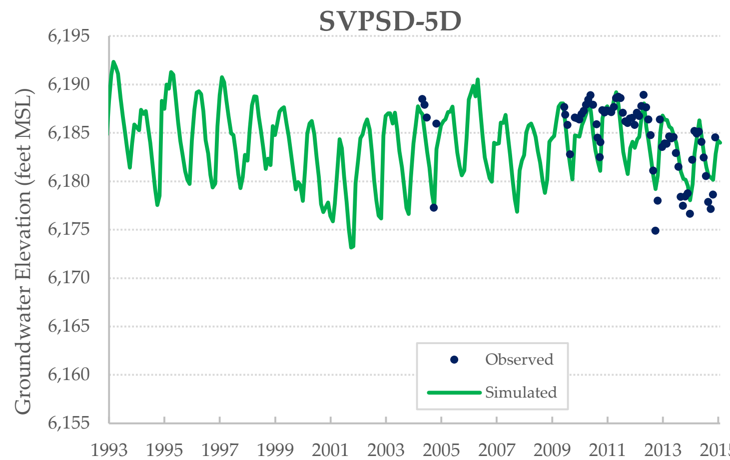

RSC-329
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated

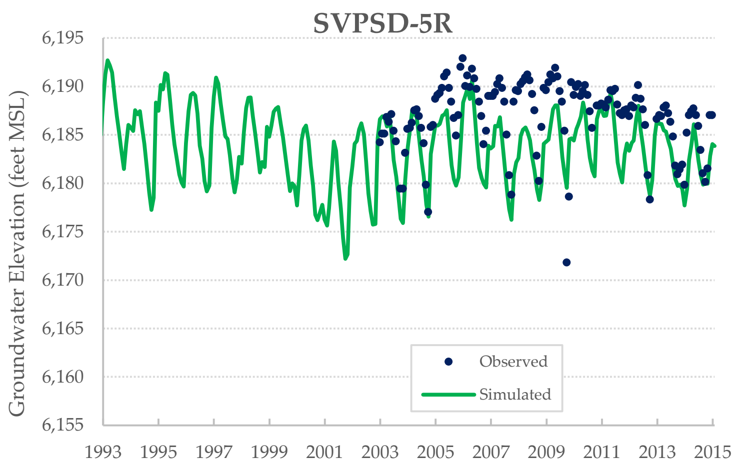

RSC-330
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated

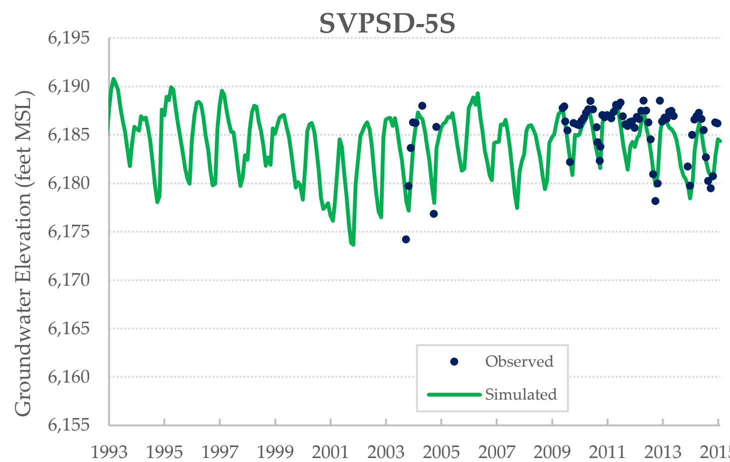

RSC-331
RSC-332
RSC-333
RSC-334
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

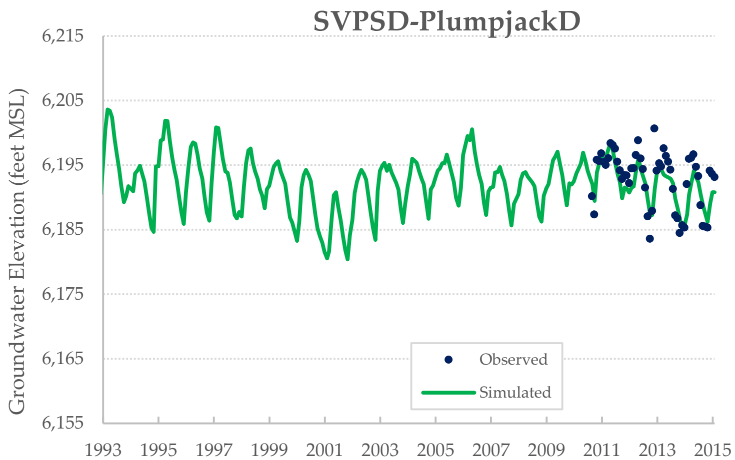

RSC-335
SVMWC-2
SVPSD-1R
SVPSD-2
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated

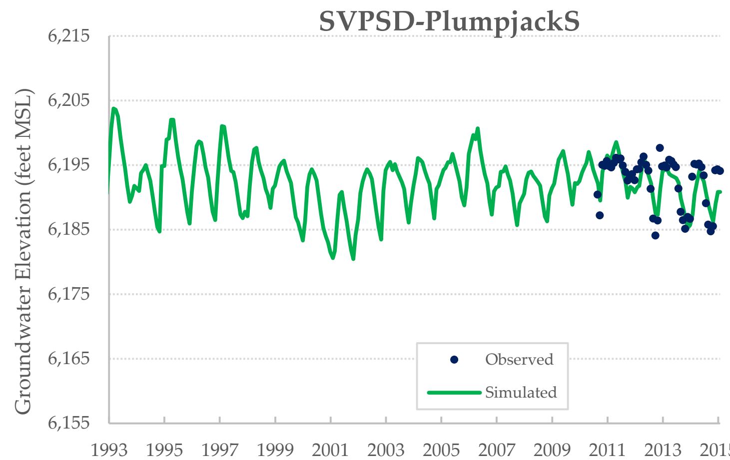

SVPSD-4R
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated

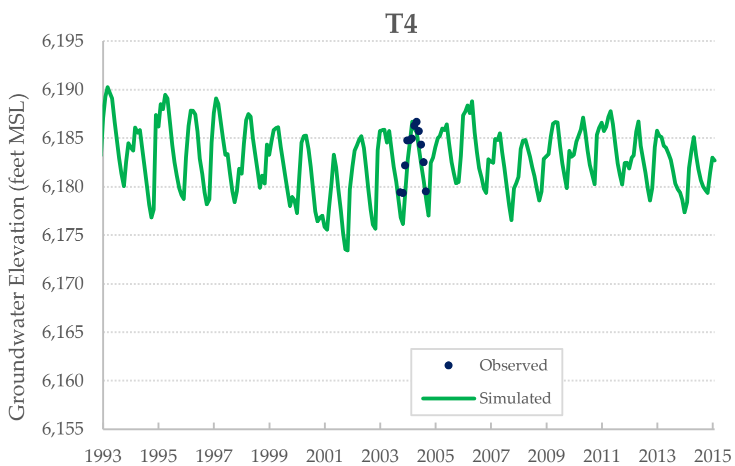

SVPSD-5D
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated


SVPSD-5R
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated


SVPSD-5S
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Observed
Simulated


SVPSD-PlumpjackD
Groundwater Elevation (feet MSL)
6,215
6,205
6,195
6,185
6,175
6,165
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated


SVPSD-PlumpjackS
Groundwater Elevation (feet MSL)
6,215
6,205
6,195
6,185
6,175
6,165
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated


T4
Groundwater Elevation (feet MSL)
6,195
6,190
6,185
6,180
6,175
6,170
6,165
6,160
6,155
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Observed
Simulated

APPENDIX D

Updated Sufficiency of Supply Assessment for Village at Squaw Valley and Other Growth, Squaw Valley California

Todd Groundwater, Farr West Engineering, and HydroMetrics WRI, July 21, 2015

TODD GROUNDWATER

July 21, 2015

TECHNICAL MEMORANDUM

To: Mike Geary, Squaw Valley Public Services District

From: Chad Taylor PG CHg and Maureen Reilly PE, Todd Groundwater
Dave Hunt PE, Farr West Engineering
Derrik Williams PG CHg, HydroMetrics WRI

Re: Updated Sufficiency of Supply Assessment for Village at Squaw Valley and Other Growth, Squaw Valley California

Squaw Valley Real Estate, LLC (SVRE) is planning to develop the Village at Squaw Valley in accordance with the Draft Village at Squaw Valley Specific Plan (SVRE 2015). The Village at Squaw Valley Specific Plan (Project) will include commercial, resort residential and recreational development. The purpose of this memorandum is to provide an update on the sufficiency of supply methodology and findings. Farr West Engineering (Farr West) has prepared a separate memorandum documenting the water demands (Farr West 2015).

1. INTRODUCTION

There are currently two water suppliers within Squaw Valley: the Squaw Valley Public Service District (SVPSD) and the Squaw Valley Mutual Water Company (SVMWC). SVPSD plans to provide potable water supply service to the Project. There are also private parties that use groundwater from the valley to serve non-potable needs, including golf course irrigation at the Resort at Squaw Creek (RSC) and snowmaking at the Squaw Valley Resort. Farr West's June 2015 memorandum documents recent historical water use by each of these suppliers and the private parties in Squaw Valley.

2. WATER DEMANDS

Future water demands for Squaw Valley have been estimated for Project and reasonably foreseeable non-project development for the next 25 years. Project specific demands were estimated by MacKay & Somps (2015) for full build-out of the Project using unit demand factors developed collaboratively with Farr West and SVPSD. The estimation of non-project water demands first required evaluation of the reasonably foreseeable development that might occur contemporaneous with the Project. Placer County prepared an estimate of this reasonably foreseeable development through the next 25 years for use in assessing non-project growth over the Project time frame (Placer County 2014). Farr West used these Placer County development projections along with historical use data and SVPSD standard unit demand factors to estimate water demands associated with the planned future non-project development through 2040 (Farr West 2015).

The water demands at the end of a 25-year period (2040) were used to evaluate sufficiency of supply. Unlike most supply assessments that provide annual estimates, future Project and non-project demands were estimated on a monthly basis. This allows accounting for the dynamic aquifer system that is largely recharged by snowmelt, such that the timing of demand affects the volume of available supply. Accordingly, the specific distribution of demands in time and space results in unique water supply availability.

The water demands evaluated in the sufficiency of supply assessment are presented by each major component in Table 1. These demand data represent the assumed monthly distribution in an average year. Assessment of monthly distribution was included in Farr West's demand calculations. Additional details relating to demand estimates are presented in Farr West's June 2015 memorandum. Table 1 also includes average historical water use from horizontal wells that do not produce groundwater from the Olympic Valley Groundwater Basin (Basin). These volumes are subtracted from the demands as this production is assumed to continue to be available at current volumes to meet existing demand in the future.

In addition to assessing monthly Project demands, MacKay & Somps also estimated the number of wells required to meet those demands (MacKay & Somps 2015). The process for estimating the number of required wells used a conservative modification of the SVPSD method of estimating peak daily demand and dividing that demand by a conservative per-well maximum pumping rate. The SVPSD estimates peak day demand by multiplying the average day demand by a peaking factor of 2.5 (ECO:LOGIC 2008). Instead of using the average daily demand calculated for the entire year, MacKay & Somps took the conservative approach of using the maximum monthly demand (the demand from August) and multiplying the daily demand rate by the 2.5 peaking factor. The resulting peak day demand was just over 700,000 gallons per day (gpd). To estimate the number of wells required to meet this demand MacKay & Somps assumed that each well could produce a maximum of 200 gallons per minute (gpm) at a duty cycle of no more than 70 percent per day (e.g. 17 hours of pumping in a 24 hour period). The resulting maximum per well production capacity is 201,600 gpd. Dividing the peak day demand by the maximum per well production capacity results in the need for four new wells (3.5 rounded up to 4). Applying this methodology to the SVPSD non-project demands at 2040 shows that the non-project demands for the peak month of July (excluding the RSC Phase 2 potable demand) will require a minimum of two additional wells above the four wells for the Project.

3. WATER SUPPLY

As noted previously, two municipal water suppliers in Squaw Valley (SVPSD and SVMWC) and two private parties are known to produce groundwater for their own use (SVR and RSC). The water used by these four entities all comes from groundwater sources that are local to Squaw Valley, as described below.

3.1 Supply Sources

Currently two sources of water supply are used on the valley floor in Squaw Valley: groundwater from the alluvial Olympic Valley Groundwater Basin and groundwater from horizontal fractured bedrock wells in the mountainous areas above the valley floor.

3.1.1 Olympic Valley Groundwater Basin

Groundwater produced from the alluvial aquifer beneath Olympic Valley has been the primary source of water supply in the area since the beginning of development in Squaw Valley. The alluvial aquifer underlying Olympic Valley is the Olympic Valley Groundwater Basin, designated by the Department of Water Resources (DWR) as Groundwater Basin Number 6-108 (DWR 2003). The Basin has been characterized multiple times by several investigators over the course of the past 40 plus years. The characterizations from these multiple studies were combined into a single description in the 2007 Olympic Valley Groundwater Management Plan (GWMP, HydroMetrics 2007a) with independent analysis and confirmation from Todd Engineers in 2012. Further refinement of the interaction between the Basin and surface water and the recharge sources for the Basin was developed in 2013 by HydroMetrics with assistance from Lawrence Livermore National Laboratory (LLNL) and the University of Nevada at Reno (UNR) (HydroMetrics 2013 and Moran 2013). A summary description of the Basin from these sources is presented below.

3.1.1.1 Physical Setting

Olympic Valley is a glacially carved valley approximately 2.5 miles long and 0.4 miles wide in the Sierra Nevada of California located west of Lake Tahoe at an elevation of approximately 6,200 feet. Steep mountains with elevations over 8,000 feet surround the valley to the north, west, and south, and the valley narrows to the east before meeting with the Truckee River. The valley is drained by Squaw Creek, which is a tributary to the Truckee River. The DWR-mapped Basin boundaries are shown on Figure 1. HydroMetrics performed more detailed evaluation of the geology of the Basin as part of the GWMP and developed refined boundaries for the Basin, which are shown in blue on Figure 1.

3.1.1.2 Groundwater Occurrence and Flow

In general, the western portion of the Basin is more coarse-grained than the eastern portion of the Basin. Well and boring logs from drilling show variation in lithology across the valley and in neighboring wells. As a result, precise correlations of lithologic units laterally within the valley have been problematic. Nonetheless, previously completed investigations have categorized geologic material in the valley into three units with similar hydrogeologic characteristics (HydroMetrics 2007a, Todd 2012).

> **Hydrogeologic Unit 1** – This unit is generally limited to the upper five to twenty feet of the basin and is composed of fine sands and silts in the western portion of the valley, with increasing fine grained material (clay, silt, and peaty organics) towards the east.
>
> **Hydrogeologic Unit 2** – This is the primary water bearing material in the valley. It is composed of gravels and sands, with silt and clay content increasing to the east.

This material is present at varying thicknesses in most of the basin, with the thickest portion in the west where the SVPSD and SVMWC production wells are located.

Hydrogeologic Unit 3 – This unit is present primarily in the eastern portion of the valley and is composed of fine grained material with occasional sand and gravel. This unit has limited production capacity and the water in it could be of low quality.

The unconsolidated sediments in each of these Hydrogeologic Units were deposited primarily by glacial, lacustrine, and fluvial processes. Groundwater is present in each of these units where they exist throughout the valley, but their relative ability to store and transmit water varies. Generally, the materials in the western portion of the Basin have a larger capacity for water supply production than those in the east. As a result, all the existing municipal water supply wells are located in this area. These units are underlain by igneous bedrock with no primary porosity, meaning that any water holding and transmitting capacity in these materials is in the form of fractures. Detailed descriptions, maps, and cross sections of these hydrogeologic units were presented in the GWMP and in Todd Engineers' Independent Analysis of Groundwater Supply (2012).

Recharge to the Basin occurs from infiltration of precipitation on the valley floor, overland flow from the mountainsides surrounding the valley, mountainfront recharge in the higher elevation sediments on the edges of the Basin, and infiltration from Squaw Creek. Recent studies by Dr. Jean Moran (2013) and HydroMetrics (2013) have provided additional documentation of the mechanisms and timings associated with recharge to the Basin. These studies showed that in the western portion of the Basin, most of the water produced by the municipal supply wells comes from mountainfront recharge occurring just above the valley floor in shallow aquifer materials along the edge of the groundwater basin (Moran 2013). This source of recharge occurs during precipitation and snowmelt, so the volume and timing of this source of water to the Basin is dependent on these factors. This recharge source assessment also showed very little evidence of flow into the Basin from fractured bedrock sources in the mountains above the valley floor, which indicates that there is little connection between the Basin and fractured bedrock groundwater. In addition, these studies found that the Basin discharges to Squaw Creek more often than it receives infiltration from this source. Moreover, the volume of discharge from the Basin to the Creek is likely greater than the volume of infiltration from the Creek to the Basin (HydroMetrics 2013).

Historical records of groundwater elevations in monitoring and production wells show that water levels peak near the same elevations in normal and wet years. The elevation of these peaks is generally near ground surface. This suggests that during most years, there is ample recharge to fill the sediments to a maximum level; above this level, recharge is rejected because the Basin is nearly completely or locally full. Rejected recharge either flows overland to Squaw Creek or it is quickly drained from the shallow portion of the Basin by Squaw Creek (HydroMetrics 2007a).

The GWMP found that even in years with below average precipitation, water levels in monitored wells rose to near the maximum elevations, indicating that the Basin was still filled to near total capacity in dry conditions. Records from years with below average precipitation did show that water levels in late summer and fall are dependent on the amount of snowmelt that flows through Squaw Creek during the spring and summer. Accordingly, this is the portion of the year during which low precipitation and high water demand could limit groundwater availability (HydroMetrics 2007a).

Groundwater flow within the Basin is generally from west to east, with some flow driven from the north and south boundaries of the basin by topographic highs. During periods of increased pumping from the municipal wellfield, the flow pattern is modified by drawdown cones surrounding the wells.

3.1.1.3 Water Supply from the Olympic Valley Groundwater Basin

Current and recent historical groundwater supply from the Basin has been assessed by Farr West as part of the estimation of Project and non-project demand (Farr West 2015). The total average production from the Basin is 871 AFY, and each of the four main water producers pumps approximately the following average annual volume from the Basin:

- SVPSD average production of 403 AFY for all municipal uses
- SVMWC average 130 AFY of municipal supply use
- SVR average of 81 AFY for snowmaking
- RSC average of 257 AFY for golf course irrigation and snowmaking combined

3.1.2 Fractured Bedrock Groundwater

Groundwater is found in fractures in the crystalline rocks surrounding the Basin. Kleinfelder & Associates (1991) mapped steeply dipping fractures and springs in the mountainsides to the south and east of the Basin. As noted above, the recent LLNL study found that a major portion of the recharge to the Basin comes from mountainfront recharge. This study also indicated that there was not a significant component of water from fractured bedrock sources present in the western portion of the Basin. This implies that there is not a strong connection between fractured bedrock groundwater occurring in the mountains above the valley and the Basin.

The SVPSD and SVMWC have active horizontal wells that draw from fractures on both the north and south sides of the valley, as shown on Figure 1. These wells are completed in fractured bedrock, and not the alluvial Basin. Horizontal wells are not equipped with pumps; water that enters the well is drained out of the opening by gravity. Therefore, the quantity of water produced by a horizontal well is generally considered to be constant from year to year, unless the capacity of the fractures connected to the well is reduced. The SVPSD and SVMWC horizontal wells do not appear to have shown reductions in supply capacity in the past. Currently, approximately 68 acre-feet per year (AFY) of municipal supply is met from these horizontal bedrock wells located outside of the Basin (Table 1). The volumes produced from these wells are included in this report because they will continue to be a source of supply used to meet demand in the future. No additional development of bedrock water supply is anticipated to meet Project or other future water demands at this time.

3.2 Groundwater Management

The primary groundwater management agency in the basin is the SVPSD. SVPSD has led the development of a GWMP in accordance with the California Water Code and in cooperation with a stakeholders group of representatives from local groundwater users, environmental organizations, regulatory agencies, and the public. The GWMP was first developed and adopted in 2007 (HydroMetrics 2007a). Groundwater condition reports have since been completed in 2008, 2009, and 2011 (HydroMetrics 2008, 2009 and 2011). The management area defined for the GWMP is smaller than the DWR Bulletin 118 groundwater basin area, as discussed above (Figure 1). The GWMP area is defined by hydrologic and geologic features that limit groundwater flow; these include low-permeability glacial moraine deposits at the eastern end of the basin. The moraine deposits, representing a relative barrier to groundwater, are not included in the GWMP.

3.3 Water Supply Availability

Several previous studies have attempted to quantify the volume of groundwater that can be produced from the Basin over some time period without causing impairment of one kind or another. Several of these studies misused the term safe yield and the annual production volumes they present are unreasonably high (Todd 2012). More recent studies completed on behalf of the SVPSD have attempted to quantify a *sustainable yield* for the Basin using the existing SVPSD model. However, these studies evaluated the maximum amount of water that could be pumped from the Basin using existing wells during a critically dry year without significantly impacting the pumping water levels of the shallowest existing well municipal supply well (West Yost 2001 and 2003). This *sustainable yield* actually is an *operational yield* that pertains more to the maintenance of specific well operations than to the potential yield of the groundwater basin (Todd 2012, Slade 2006).

These attempts to quantify a *sustainable yield* reported a wide range of maximum groundwater production volumes (West Yost 2001, Williams 2004, and Todd 2012). The large range of reported maximum supply values was the result of variations in the timing and distribution of demand and pumping. The wide range indicates that the assumptions regarding these distribution factors play a significant part in the results of the analyses. Without firmly established and agreed upon criteria, a sustainable yield cannot be quantified. In addition, a sustainable yield analysis resulting in a single, static value for groundwater availability oversimplifies the dynamic and complex Olympic Valley Groundwater Basin system.

Evaluation of the occurrence and flow of groundwater in the Basin and the related water balance has shown that the groundwater system in Squaw Valley is highly dynamic and responsive to the timing and spatial distribution of recharge, demands, and pumping. This small groundwater system has a very high volume of water flowing through the watershed on an annual basis, which far exceeds the volume of groundwater storage or use (Todd 2012). This is clearly illustrated by the large volume of rejected recharge that has been identified by HydroMetrics and others (HydroMetrics 2013, Todd 2012).

It is very difficult to quantify the supply capacity of groundwater systems with large volumes of rejected recharge, because increased groundwater pumping can directly increase the volume of recharge that flows into the Basin. Therefore, the relationship between the timing of demand and recharge to the Basin is important to the availability of supply in the system. In these circumstances, it is necessary to evaluate the important water producing areas of the Basin over time, instead of individual wells. It is also impractical to establish a single value representing maximum annual groundwater availability such as a *safe* or *sustainable yield,* because the seasonal distribution of demand over the course of the year could change the total volume of water that can be produced. The sufficiency of supply evaluation below presents and applies a methodology for comparing demand to supply availability in the Basin.

4. WATER SUPPLY SUFFICIENCY

The proposed Project and non-project growth over the next 25 years represent an increase in the water demand within Squaw Valley of 383 AFY. The Project will require 240 AFY of this increase, and the non-project development presents an additional 143 AFY of demand. The total projected water demand represents a 44 percent increase over the average annual volume (871 AFY) currently used in the valley.

Given the highly dynamic nature and small size of the Basin, previous studies have found it impractical to define a single static supply availability value (i.e., a safe, sustainable, or perennial yield) for this groundwater resource (Todd 2012).

SVPSD developed a numerical groundwater model of the basin to assist in the evaluation of supply and management of groundwater in the valley. This model was prepared and is maintained and updated by HydroMetrics for SVPSD. The SVPSD groundwater model has been used in the past as a tool for managing groundwater supply, planning for future growth, and evaluating potential water supply sources for specific developments in Squaw Valley. The model was previously used in the evaluation and approval of new developments at the RSC and the PlumpJack properties.

The volume of groundwater that can be produced from the Basin in any year is dependent on four factors:

1. Timing of recharge to the Basin (i.e. precipitation and snowmelt)
2. Timing of the demand
3. Location of pumping wells
4. Acceptable Basin response to pumping for long-term sustainability

Factor 1 – Timing of recharge to the Basin

When potential recharge is available in the Basin is an important component of water supply sufficiency. However, this factor is largely dictated by hydrologic and weather conditions. The volume and timing of potential recharge to the aquifer used in the evaluation of supply sufficiency are based on recorded historical data.

Factor 2 – Timing of demand
As noted previously, the relationship between the timing of demand for groundwater supply and recharge to the Basin has a significant impact on the balance of water available in Squaw Valley. Since the timing of demand is determined by the quantity of each type of development in the valley, accurate estimation of development and associated water demands is important. Different temporal distributions of demand with the same annual totals could have very different effects on groundwater elevations and availability in the Basin. Therefore, any changes in the monthly distribution of demand will require re-evaluation to assess sufficiency of supply.

The assessment of supply sufficiency presented below uses the estimated water demands at 2040 according to the temporal distribution that resulted from the specific quantity and type of demand anticipated (Farr West 2015). Consequently, the results of this analysis are valid only for this specific demand distribution.

Factor 3 – Location of pumping wells
Historically, groundwater pumping to provide municipal water supply has been limited to a few wells in the western portion of the Basin (existing wells on Table 2 and Figures 1 and 2). The existing wells are capable of producing more water than is currently used in Squaw Valley, but previous evaluations using only the existing wells showed that they would not be capable of meeting the projected demands at 2040 because production of higher volumes from the limited wellfield would cause too much drawdown in the existing wells for proper function (Williams 2004). Therefore, an expanded wellfield with new wells will be required to meet these projected demands. The locations of the new wells are important. If wells are too close to one another or located in disadvantageous locations, pumping could cause groundwater elevation declines that restrict groundwater supply availability or interfere with well and pump operability.

The sufficiency of water supply in the Basin has been assessed by adding potential new wells in advantageous locations and simulating the effects of pumping those wells along with the existing wells to meet total water demands at 2040. As noted above, a total of four new wells are estimated to be required to meet the demands of the Project (MacKay & Somps 2015) and two additional wells are required to meet the SVPSD non-project demands at 2040. In order to assess the capacity of the Basin to produce water, more than just the minimum number of potential new well locations was identified. Limiting the potential new well sites to only the six new SVPSD wells required to meet demand at 2040 would have shown the ability of a specific wellfield to meet demands, not the Basin as a whole.

The potential new wells were identified by evaluating geology, geometry, hydrostratigraphy, aquifer production capacity, and development plans for the western portion of the Basin. Nine potential new wells sites were identified through this process. In addition, a single SVPSD well (Well-1R) may need to be replaced to accommodate the Project. A replacement location for this well has been identified, as shown on Figure 2. All of the potential new wells and the replacement well were used in conjunction with the existing wells shown in Table 2 and Figure 2 in assessing the sufficiency of supply. The number and locations of wells has the potential to change the outcome of this analysis.

Factor 4 – Acceptable Basin response to pumping for long-term sustainability
In order to assess sufficiency of a groundwater supply source to meet demand, it is necessary to have a criterion or set of criteria defining acceptable Basin responses to pumping. As discussed above, previous attempts to establish such a criterion have been problematic. In order to assess future groundwater supply availability, it is necessary to have a set of criteria that pertains to the entire productive portion of the Basin, not simply to operational parameters in specific existing or potential new wells.

The simulated results of supplying total 2040 demand from the expanded wellfield have been compared to a set of criteria developed for assessing wellfield conditions. Specifics relating to this approach are described below.

4.1 Numerical Groundwater Model

The existing SVPSD model was first constructed in 2001 (Williams 2001). The model was constructed to simulate the Olympic Valley Groundwater Basin using the widely-accepted MODFLOW software developed by the United States Geological Survey (USGS). The boundaries of the Model extend to the modified Basin boundaries developed by HydroMetrics and shown on Figure 1.

Since its original construction, the model has been updated multiple times to incorporate new data and refine conceptualizations (West Yost 2003, HydroMetrics 2006, 2007b, 2014, and 2015). The model was updated in 2014 following significant additional data collection relating to Squaw Creek (HydroMetrics 2013). This update included incorporation of groundwater elevation, streamflow, stream bed conductance, and climate data and an extension of the model period and recalibration to simulate conditions from May 1992 through December 2011. Following this major documented model update, HydroMetrics implemented additional changes and successfully recalibrated the model to accommodate simulation of future conditions (HydroMetrics 2014). The model was updated again in 2015 to expand the time period and include recent hydrologic conditions, including the dry years of 2012 through 2014. This most recent update included processing and incorporation of groundwater elevation, streamflow, and climate data through January 2015. In addition, the methodology for calculating recharge from precipitation was modified to account for limited infiltration during summer storm events, effectively reducing summer month infiltration (HydroMetrics 2015). The current version of the model was assessed and found to adequately simulate groundwater elevations for the period from May 1992 through January 2015 (HydroMetrics 2015).

The current version of the numerical model is a good tool for simulating changed conditions and management practice alternatives. The model can be used to simulate future conditions and predict how increased pumping will affect Basin water levels and the water balance. For the assessment of supply sufficiency, the model is run in a predictive mode with potential new wells added to the existing wellfield as discussed above in Section 4 and pumping distributed as described below in Section 4.2. The results of the model simulations were then evaluated against criteria described in Section 4.3.

4.2 Simulation of Groundwater Production to Meet Projected Demands

The projected demands at 2040 were distributed by pumper and by well. The monthly pumping volumes by well required to meet the 2040 average year demand are presented in Table 3. Average annual demands were used because there are currently no methods for assessing the magnitude of demand reductions that may occur in Squaw Valley as a result of mandatory water use cuts during drought periods. The assumption that water demand does not decrease during dry conditions results in conservatively high demand estimates.

The monthly production volumes by well shown in Table 3 were applied to the latest version of the model described above. Groundwater models are a collection of input files representing components of the groundwater system, a set of equations for how water moves, and a computer code that combines the inputs and solves the equations to simulate flow in the model. In the case of the Basin model, the input parameters are aquifer geometry (model grid and elevations of layer tops and bottoms), aquifer parameters (hydraulic conductivity and storage coefficients), recharge, streamflow, and pumping. Recharge in the Basin model is a combination of precipitation, irrigation and municipal return flows, and sewer pipe gains and losses. Most of the model inputs for the future demand model simulation were kept the same as those from the recently updated and calibrated model, because for the most part aspects such as aquifer parameters, aquifer geometry, and boundary conditions will not change in the future. The following model input files were assigned to represent future conditions:

- Recharge – The precipitation component of the recharge inputs used measured precipitation from October 1992 through December 2014, which is all of the full water years represented in the model, plus the last three months of 2014. A water year is the 12 month period from October 1st to September 30th, and designated by the year in which it ends. The model uses precipitation data for Olympic Valley from the Squaw Valley Fire Station gage maintained by SVPSD to simulate recharge. Precipitation that falls on the mountainous areas of the watershed above the Valley Floor is not used in the Model as a direct or modified input variable. Mountain precipitation is represented in the Model only through measured stream discharge, which is continuously gaged and recorded in Squaw Creek at the western end of the Valley.

  The time period of October 1992 through December 2014 is used in the model because it is the timeframe over which the data and information required to populate the model are available. Prior to the beginning of the model time period there were insufficient groundwater production, elevation, and climate record data to allow the model to be populated or calibrated. The period from October 1992 through December 2014 includes a representative range of hydrologic conditions for Squaw Valley (HydroMetrics 2014).

  The hydrologic inputs for recharge were kept at historical values to represent variable hydrologic conditions over a long period of time. This facilitates the evaluation of normal, wet, and dry periods. The portions of recharge that come from irrigation and municipal return flows and sewer pipe gains and losses are all calculated as a function of the delivered water within the SVPSD, SVMWC, and RSC water production and distribution systems. These components were calculated from the average demand data presented in Table 1.

- Streamflow – Flow in Squaw Creek for the period from October 1992 through December 2014 was used to represent future conditions, as in the case of precipitation. Sqauw Creek flow in the Model is developed from stream discharge measurements collected by the Friends of Squaw Creek (FoSC 2015) from gages at the western end of the Valley.

- Pumping – The volume, timing, and spatial distribution of pumping was assigned to an expanded wellfield. The larger wellfield includes most of the existing municipal supply wells and nine new wells to meet increased SVPSD demands. The locations of all the wells are shown on Figure 2, and basic information about each well is presented in Table 2.

  As noted above, the Project and non-project demands are estimated to only require six new wells. However, in order to assess the capacity of the aquifer to meet demand and limit the effects of a specific wellfield arrangement on the evaluation, wells were placed in all of the locations identified as being favorable for groundwater production. The potential new wells were placed in locations where no Project buildings are planned and were selected to take advantage of deep and productive areas, maintain distance between wells to minimize interference, maximize distance from Squaw Creek, and distribute pumping over a large area to reduce cumulative drawdown effects in any one area of the Basin. One of the existing SVPSD wells (SVPSD-1R) is in a location where a new building is planned for the Project. SVRE plans to replace this well in the location shown as SVPSD-1RR on Figure 2. All of the other existing water supply wells will remain intact.

  Total pumping volumes for each pumper (i.e., SVPSD, SVMWC, RSC, and SVR) were set to equal the average demands distributed by month shown in Table 3. These total demands were then distributed to specific wells according to the following logic:

  - Total SVPSD demand was distributed to the existing and new wells equally each month, with one exception. Equal distribution of pumping to all the wells was used for two reasons:

    1. Spreading pumping out among a large number of wells so that no one well is responsible for pumping large volumes at any given time reduces the discrete water level declines. This balanced pumping distribution allows withdrawals from the Basin to be more evenly spread throughout the area of the wellfield, which reduces water level declines in any one area and minimizes impacts between wells.

2. The actual distribution of pumping in any wellfield is the result of management decisions that take into account distribution system pressures and flow rates, storage considerations, water treatment requirement, equipment maintenance, etc. Any attempt to predict the outcome of this set of operational and management decisions would be incorrect and overly complicated.

The exception to the demand distribution methodology is the demand for the RSC Phase 2 development, which was previously approved for development by the County and the SVPSD. SVPSD has agreed to serve potable water to the expansion in accordance with a development agreement (DA) that specifies the volume and timing of the associated potable demands (HydroMetrics 2006 and 2007b). The DA requires RSC to dedicate their Well 18-3R (RSC-18-3R) to SVPSD to meet those demands. As a result, the planned RSC Phase 2 demands are all assigned to RSC-18-3R, while the rest of the SVPSD demands at 2040 are spread equally among the remaining SVPSD wells.

The monthly pumping rates in the existing SVPSD wells are actually lower in the modeled 2040 pumping scenario than in current average conditions. This is the result of the wider distribution of groundwater production to more wells in the expanded wellfield. Existing SVPSD Basin groundwater production from four wells was approximately 377 AFY on average (94 AFY per well). In the modeled 2040 pumping scenario there are 14 SVPSD wells producing a total of 760 AFY, or approximately 54 AFY per well (Table 3).

- SVMWC demand was distributed to the two existing SVMWC wells according to percentage each produced in the recent historical period.

- RSC demand for irrigation and snowmaking listed on Table 3 will be satisfied from existing and planned RSC wells. The same DA that governs the volume, timing, and supply source of potable demand for Phase 2 at RSC also includes specifications for the volume and timing of non-potable groundwater production, including reductions in irrigation use. A schedule for the distribution of these demands to wells on RSC property was developed when the SVPSD was assessing service of RSC Phase 2 (HydroMetrics 2006 and 2007b).

- Demand for future SVR snowmaking is assumed to be equal to the recent historical volumes plus a growth factor of ten percent. Pumping to meet these demands is assumed to be distributed proportionally to the existing wells on Figure 2 as it was in the recent historical period.

Monthly distribution of pumping to all active wells in the predictive model is shown on Table 3. These monthly pumping rates represent average year production for each well. These average year values were assumed to represent pumping throughout the model period. Therefore, pumping volume, distribution, and timing input to the model is the same for every year from October 1992 through December 2014.

The input files described above were all developed for 2040 conditions and run for every year of the model period. Since the demands estimated by Farr West (2015) are the highest at the end of the period of study (2040), running the model with those demands for every year represents a conservative approach to assessing supply sufficiency.

4.3 Criteria for Evaluating Sufficient Water Supply

As noted in the discussion of water supply in Section 3, no reliable estimates of maximum groundwater supply availability or agreed-upon criteria for evaluating this parameter have been developed in previous work completed in Squaw Valley. As a result, criteria have been developed against which simulated (modeled) groundwater elevations can be compared.

4.3.1 Development of Sufficiency of Supply Criteria

The development of the set of criteria defining an acceptable Basin response to pumping for long-term sustainability (Factor 4 above) was a detailed and exhaustive process. The criteria incorporate operational concerns in existing wells, consider Basin viability in proposed new well locations, and maintain groundwater elevations in the Basin at acceptable levels.

One common method for assessing supply sufficiency is to estimate the portion of the water balance that goes towards subsurface outflow and evaluate the annual portion that can be used without impacting groundwater availability. In the case of the Basin, the eastern end of the Basin has very low hydraulic conductivity and acts as a lateral aquiclude (Williams 2001) restricting the flow of groundwater out of the Basin to the east. As a result, the Basin fills up and water that could potentially infiltrate into the Basin instead leaves the valley during peak runoff periods. This phenomenon of *rejected recharge* is due to the much larger volume of potential recharge water (precipitation and snowmelt) that flows through the valley on an annual basis relative to available storage capacity in the Basin (HydroMetrics 2013, Todd 2012). For a water balance, this means that the volume of groundwater pumping outflow has little to no effect on the volume of subsurface outflow, but a large impact on the volume of recharge into the Basin. Therefore, evaluation of the water balance components was not useful in the development of sufficiency of supply criteria.

One of the most distinguishing characteristics of the Basin is the pattern of winter and spring groundwater elevations at or near historical highs year after year regardless of hydrologic conditions. As noted previously in this memorandum, observations of historical groundwater elevations and production in the valley and results of modeled conditions show that the Basin generally fills to the same levels every year in the winter and spring months. Even in dry years when groundwater elevations sometimes fall to relatively low levels in the late summer and fall, they generally recover to high elevations in the winter and spring regardless of whether the area is experiencing average, wet, or dry hydrologic conditions. This is another example of rejected recharge in the Basin (HydroMetrics 2013, Todd 2012). In these cases, the relationship between potential recharge volume and available groundwater capacity implies that additional groundwater production-related water level declines would not cause year-on-year reductions in groundwater elevations or availability, but would instead induce increased recharge to the Basin. These same groundwater elevation patterns also show that the late summer and fall months are the times when water levels are lowest and groundwater supply availability is potentially limited.

Interactions between groundwater and Squaw Creek were considered in the early stages of criteria development as well. The model can simulate changes in volumetric flow between groundwater and the creek. It can also simulate volumetric flow in the creek, but the accuracy of these predictions and the resolution of the results are low due to the limited available streamflow calibration parameters. Impacts to streamflow are more related to biological considerations than to groundwater conditions, which are in turn dependent on additional factors including creek velocity, flow depth, and temperature and their effect on individual species. No previous investigations have identified specific flow volume and timing requirements for Squaw Creek. Such an analysis is being prepared for inclusion in an Environmental Impact Report (EIR) for the Project at this time, but the results are not available for inclusion in water supply sufficiency criteria.

The groundwater elevation patterns and associated observations regarding recharge and low water level periods guided the development of the supply sufficiency criteria toward a water-level based evaluation. Groundwater elevations in an unconfined aquifer without context specific to the location or aquifer are not meaningful. A more useful consideration is the proportion of the Basin that is saturated, and the maximum potential saturation in either the entire Basin or a specific location. Saturated thickness is the groundwater elevation (head) in a well minus the elevation of the bottom of the aquifer at that location. The maximum saturated thickness occurs when water levels are the highest. The percent saturated thickness is a simple metric that combines the saturated thickness at any given time with the maximum saturated thickness. Percent saturated thickness is the saturated thickness at a location and time divided by the maximum saturated thickness for that location. The maximum saturated thickness values at specific locations do not change, and were derived from model simulations representing historical actual pumping conditions (baseline conditions).

Further evaluation of a groundwater-elevation based criteria using saturated thickness and percent saturation was completed to identify the locations in the Basin that would be most affected by reduced groundwater elevations. The evaluation focused on the following elements:

1. Because groundwater production at 2040 is proposed to come almost exclusively from the western portion of the wellfield (Figure 1), the criteria should focus on this area.
2. Groundwater elevations in the area of interest should be maintained at a reasonable level that will not risk impeding the ability of the Basin to store and transmit water.
3. Operation of existing and new municipal wells should be considered.

The western portion of the Basin is the most productive groundwater area in Squaw Valley. The existing SVPSD and SVMWC wells and the proposed new municipal wells are all within this area. Previous studies have identified a change in groundwater elevations at the eastern edge of this area, which has been interpreted as a hydraulic separation of some kind (Kleinfelder 2000, Williams 2001, West Yost 2001, HydroMetrics 2013). This appears to indicate that there could be a separation between the western and eastern portions of the Basin, which supports the concept of evaluating the western portion on its own.

One well is proposed for municipal supply use that is outside the western portion of the Basin, RSC-18-3R (Figure 2). However, this well and the production associated with it was already assessed as part of the RSC Phase 2 project approval (HydroMetrics 2007b). The previously completed assessment indicated little to no interaction between the wells in the western portion of the Basin and RSC-18-3R.

Technical literature were reviewed to locate any guidance that might be available for maintaining groundwater elevations at a reasonable level that does not risk impeding Basin capacity. Driscoll (1986) states that, "Theoretical considerations and experience have shown that screening of the bottom one-third to one-half of an aquifer less than 150 feet thick provides the optimum design for … unconfined aquifers." Driscoll goes on to say that, "it is impractical to pump a well in an unconfined aquifer at a drawdown that exceeds two thirds the thickness of the water bearing sediments." Therefore, at a minimum between 33 and 50 percent of the Basin must remain saturated.

The development of criteria for assessing supply sufficiency also evaluated operational considerations. These considerations include maintaining water levels above screens, preserving minimum pump submergence depths, and limiting interference between wells. All of these factors were reviewed for the existing SVPSD and SVMWC Basin municipal wells. Because the proposed new wells have not been designed or installed yet, no screen elevation or pump setting depths could be used to evaluate these operational considerations in the proposed wells. Assessment of Basin thickness and historical saturation was used in the new well locations in the absence of construction or equipment information. The review of these operational and Basin character parameters for the existing and new wells showed that modeled water levels in specific wells had been as low as 65 percent saturated thickness in the past without causing operational problems.

The operational review indicated a threshold of 65 percent saturated thickness, and the literature review identified a range of suggested minimum saturated thicknesses of 33 to 50 percent. Because the operational review is a more conservative threshold (i.e. a greater saturated thickness with higher groundwater elevations) that value was chosen as the basis of the threshold for evaluating sufficiency.

The future forecast predictive modeling uses average annual groundwater production and equal distribution of monthly demand among all the SVPSD wells. As mentioned earlier, the average annual demand was used in the model because there have been no reductions in demand relating to drought or other conditions in the past. In addition, pumping was distributed equally to all SVPSD wells to minimize impacts and reduce assumptions relating to wellfield operation and management. Because the demand and distribution of pumping are averaged across the wellfield and there is a desire to focus on the entire western portion of the Basin, it made more sense to apply the threshold to this area of the Basin as a whole, rather than to individual existing or proposed new wells. These considerations directed the criteria development to apply the threshold to the average percent saturation in all the western wellfield wells instead of in individual wells. The western wellfield refers to only those existing and new municipal supply wells in the western portion of the Basin where most of the groundwater production takes place. These wells are all of the municipal supply wells west of and including SVMWC-2.

However, because there is an operational component to the threshold, a check was performed using model simulations to identify any difference in overall groundwater supply when the threshold was applied to individual wells or to the entire wellfield. These simulations showed that varying pumping among individual wells to maximize water availability produced similar groundwater availability results to assessing average percent saturated thickness from all wellfield wells. The existing and new wells are relatively well distributed throughout the western portion of the Basin, which makes them appropriate for use as targets for evaluating this area as a whole. Therefore, the average percent saturation in the western wellfield wells is a good indicator of the overall condition of this portion of the Basin.

Experience with groundwater production in other unconfined aquifers in California has shown that in times of extreme water shortage, it is sometimes operationally necessary to produce water even though water levels in wells could be below operational thresholds for short periods, so long as these situations are not a frequent part of a long term management strategy. Managing wells and aquifers in this manner should not cause long term problems so long as these conditions do not occur with regularity or extend for significant periods of time and do not result in any reduction in water quality of damage to equipment. In the Basin, historical groundwater elevation records show that dry periods can cause declining water levels for six months during the year (HydroMetrics 2007a). The criteria should allow water levels to fall below the 65 percent threshold to permit flexibility in supplying water, but limit the duration of such exceedances to no more than half of the declining water level period. Therefore, the criteria include allowance for the average percent saturation to fall below the 65 percent threshold for no more than three consecutive months. In addition, the number of times that such exceedances can happen within the model period was limited to four occurrences.

4.3.2 Sufficiency of Supply Criteria

The criteria that resulted from the detailed evaluation presented above are as follows:

- Average saturated thickness in the western municipal wellfield wells (existing and proposed new) may not fall below 65 percent for more than 3 consecutive months or more than 4 times total over the model simulation period.

As noted previously, saturated thickness is the groundwater elevation in a location minus the elevation of the bottom of the Basin at that location. Maximum saturated thickness is the highest groundwater elevation minus the Basin bottom elevation. The maximum saturated thickness values at specific locations do not change, and these values were derived for the existing and new well locations from model runs representing historical actual pumping conditions in the calibrated model. Percent saturated thickness for any location and time is the saturated thickness at that location and time divided by the maximum saturated thickness for that location.

These criteria should not be taken as recommendations for operational practices. New wells will need to be designed and constructed to maximize operational reliability and flexibility, based on location-specific hydrogeology. While there is no lower limit to percent saturation proposed for the short exceedances of the 65 percent threshold, in practice saturated thicknesses in any given month are affected by the preceding months, so extreme exceedance of this threshold in any month or months will result in exceedances of longer than the 3 consecutive month allowance.

While the criteria were developed in consideration of the elements presented in Section 4.3.1, they do rely on model simulated results. The SVPSD Basin model is, like all groundwater models, an approximation of reality. The model has grid cells ranging from 625 to 10,000 square feet in area. Simulated groundwater elevations in any location represent an average over the entire area and thickness of the particular cell. The model was developed to simulate volumetric flow in the Basin, but lacks the granularity to predict exact and absolute differences in groundwater elevations at discrete locations such as wells.

4.3.3 Sufficiency in Single and Multiple Year Droughts

The model was applied to simulate future demand conditions (total demand at 2040) and provide information to evaluate groundwater elevations in the Basin over a 23 year hydrologic period. The recharge and creek flow for this model period represent the same hydrological conditions as the period from October 1992 through December 2014. This is the same period that was used in the calibrated model (HydroMetrics 2015).

Historical drought conditions are simulated in the current version of the model. While the model was updated to include the most recent statewide drought of 2012 through 2014, this was neither the most severe single nor multiple year dry period on the Olympic Valley floor. Precipitation records from the Squaw Valley Fire Station gage indicate that between water year 1993 and water year 2014, the single driest year was 2001, when precipitation on the valley floor was just under 40 percent of average. The Squaw Valley Fire Station gage precipitation data show that the driest multiple year dry period in this time was water year 2000 through water year 2002, when the three year precipitation total was just under 64 percent of average (HydroMetrics 2015). Evaluating single and multiple dry year periods specifically focuses on the effects of drought on the water supply source. In groundwater basins, water levels are generally significantly lower during single and multiple year droughts. It is during these drought periods that average percent saturation would be most likely not to meet the percent saturation threshold.

Future changes in climate patterns may have an effect on precipitation volumes and timing. However, it is not possible to estimate groundwater elevations in the Basin based on projections of precipitation alone, as the rate of precipitation is not an indicator of Basin water levels and the relationship between precipitation on the watershed and water levels is not linear. The groundwater basin is relatively small when compared with the larger watershed. In average years, only a small portion of snowmelt recharges the groundwater; most of the snowmelt and creek flow continue to flow out of the basin and do not recharge the groundwater as the basin fills up. Decreased snowfall also indicates increased artificial snowmaking and low water demand due to reduced visitors, which add significant uncertainty to any attempt to generate approximations of future conditions where the effects of variation in weather conditions have not yet affected the Basin.

4.4 Modeling Results

A groundwater model simulates water elevations for every time step within its full time period. The SVPSD model is constructed with monthly time steps, which means that there are individual groundwater elevation results for every month in the model period of October 1992 through December 2014. The simulated results for the municipal wells in the western wellfield (the new and existing SVPSD and existing SVMWC wells in Table 2 and on Figure 2, with the exception of RSC-18-3R) were extracted from the model and used to calculate saturated thicknesses for each month in the model time period. These are the wells used for application of the criteria for evaluating supply sufficiency described above.

To assess if there is a sufficient water supply for the Project and other future water demands, the simulated Basin responses in the municipal supply wells in the western portion of the Basin were evaluated against the criteria discussed above. The percent saturation results are shown graphically on Figure 3. The average percent saturation for all of the wells combined is also shown on Figure 3 as a bold red line. The modeled results are also shown as absolute saturated thickness by month for each well on Figure 4.

The results of the modeling analysis indicate that, over the entire modeled period, the average percent saturation ranged from 77 to 99 percent, well above the 65 percent criteria. This analysis shows that there is sufficient supply to meet the Project and non-project demands in 2040 with a margin of safety. As expected, the lowest groundwater elevations generally occurred during the fall in drought years, which shows that these time periods are the most important for water supply in Squaw Valley.

Comparison of the model simulated results to the criteria shows that there is sufficient supply to meet the Project and non-project demands through 2040 with a margin of safety. While the modeled minimum average percent saturated thickness results are considerably above the 65 percent criteria, there is no way to estimate how much more groundwater could be produced without further model simulations. Such simulations would have to be prepared to simulate the monthly distribution of demands past 2040, because the timing of demands compared to recharge is an important factor in how simulated groundwater elevations respond to increased groundwater use.

Not only does the average value not fall below the 65 percent criteria, but no individual existing or potential future well of the 15 in the modeled western wellfield ever falls below this threshold.

The model results include hydrologic conditions representing dry years. The model timeframe corresponding to water year 2001 represents hydrologic conditions equivalent to a single dry year period, and the modeled time of water year 2000 through water year 2002 represents a multiple dry year period. The minimum modeled average percent saturation during the single year dry period (water year 2001) and multiple dry year period (water years 2000 through 2002) was 77percent. The simulated results for these dry water years show good correlation between water year precipitation totals and groundwater elevations, especially in multiple dry year periods. However, not all of the variations in the simulated saturated thicknesses shown on Figures 3 and 4 relate to annualized precipitation patterns. This demonstrates that precipitation alone is not a predictor of groundwater elevations. The timing of high and low groundwater elevations is dependent on monthly distribution of precipitation, streamflow, pumping, and return flows. The temporal distribution and relationships between these factors produces the wide variation in saturated thickness shown in the model results.

It is important to note that the percent saturation values are based the modeled results from pumping in the well locations shown in Figure 2 with the distribution of pumping shown on Table 3. Other combinations of pumping locations (e.g. different wells) using the same monthly demand distribution and total annual volumes could also be able to meet supply while still passing the criteria, but each would need to be tested independently. Similarly, while the modeling indicates there is a margin of safety above the demands simulated for 2040 using the modeled wells shown in Table 2 and Figure 2, the ability of the Basin to meet additional demands will depend on the distribution of demand in time and the distribution of pumping in the Basin.

4.5 Conclusions

This memorandum documents the results of modeled groundwater supply sufficiency for the specific demand distribution developed for the Project and non-project development within Squaw Valley through 2040. These demands were distributed to the appropriate pumpers and then to specific well locations primarily within the most productive groundwater supply portions of the valley. The modeled results of this pumping distribution show that there is sufficient water supply to meet the estimated Project and non-project demands at 2040.

For the purposes of the determining the sufficiency of supply, the Project and non-project demands in the SVPSD service area were distributed evenly over three of the existing and one replacement SVPSD well and nine potential new SVPSD wells in the western wellfield. The same demands (volume and timing) could also be pumped from other well field configurations and pass the criteria, assuming that they are located in the western portion of the model.

This sufficiency of supply scenario focused on meeting the total demand. Phasing of well development, pumping distributions, and well sites could vary based on available land, phasing of the Project and non-project demands.

5. REFERENCES

California Department of Water Resources (DWR), 2003, California's Groundwater, Update 2003, Bulletin No.118, October 2003: http://www.water.ca.gov/groundwater/bulletin118/update2003.cfm.

Driscoll, Fletcher G., 1986, Groundwater and Wells, Second Edition, 1986.

ECO:LOGIC Engineering, LLC, 2008, Squaw Valley Public Service District 2007 Capacity and Reliability Study Update, February 2008.

Farr West Engineering, 2015, Squaw Valley Public Service District Water Demand Projections through 2040, June 10, 2015.

Friends of Squaw Creek (FoSC), 2015, Comprehensive Annual Streamflow Analysis, http://www.friendsofsquawcreek.org/stream-flow-data.html, last accessed May 2015.

HydroMetrics, 2006, Resort at Squaw Creek Phase II Development Water Supply Modeling, report to Squaw Valley Public Service District, February 2006.

HydroMetrics, 2007a, Olympic Valley Groundwater Management Plan, May 2007.

HydroMetrics, 2007b, Resort at Squaw Creek Phase II Development Revised Water Supply Modeling, report to Squaw Valley Public Service District, April 2007.

HydroMetrics, 2008, Water Year 2007 Annual Review and Report, Olympic Valley California, March 2008.

HydroMetrics, 2009, Water Year 2008 Annual Review and Report, Olympic Valley California, March 2009.

HydroMetrics, 2011, Water Year 2010 Biennial Review and Report, Olympic Valley California, July 2011.

HydroMetrics Water Resources, Inc., 2013, Olympic Valley Creek-Aquifer Study Final Report, November 2013.

HydroMetrics Water Resources, Inc., 2014, Squaw Valley Groundwater Model 2014 Recalibration, June 2014.

HydroMetrics Water Resources, Inc., 2015, Squaw Valley Groundwater Model Update 2015, July 6, 2015.

Kleinfelder, 1991, Phase I Water Resources Investigation, Feasibility Study for Installation of Horizontal Wells at the Resort at Squaw Creek, Squaw Valley, California, November 19, 1991.

Kleinfelder, 2000, Technical Memorandum of Squaw Valley Groundwater Background Data, February 15, 2000.

MacKay & Somps, 2015, Updated Water Study, Village at Squaw Valley (V@SV), June 9, 2015.

Moran, Jean, PhD, 2013, Examination of Groundwater Inflow to Squaw Creek Using Radon and Other Tracers, October 2013.

Placer County Planning Services Division, 2014, Absorption Schedule Technical Memorandum, Village at Squaw Valley Specific Plan Water Supply Assessment, April 8, 2014.

Slade, R.C., 2006, Preliminary Draft Technical Memorandum, Results of Hydrogeologic Peer Review of May 2005 Report by West Yost and Associates, February 14, 2006.

Squaw Valley Real Estate, LLC, 2015, The Village at Squaw Valley Specific Plan, Draft, April 2015.

Todd Engineers, 2012, Independent Analysis of Groundwater Supply, Olympic Valley Groundwater Basin, December 2012.

West Yost & Associates (West Yost), 2001, Squaw Valley Groundwater Development and Utilization Feasibility Study, October, 2001.

West Yost & Associates (West Yost), 2003, Squaw Valley Groundwater Development and Utilization Feasibility Study Update, August 14, 2003.

Williams, Derrik, 2001, Groundwater Model Report, June 2001.

Williams, Derrik, 2004, 2004 Updated Sustainable Yield Analysis, August 30, 2004.

TABLES

Table 1. Average Year Total Demand by Month at 2040

All values in Acre-Feet

Month	Squaw Valley Public Services District (SVPSD)[1]					Squaw Valley Mutual Water Company (SVMWC)[2]		Resort at Squaw Creek[3]		Squaw Valley Resort Snowmaking[4]	Total Average Year Demand by Month	Average Horizontal Well Production[5]			Demand from Olympic Valley Groundwater Basin[6]
	Existing Demand	Project Demand	New Single Family Demand	New Resort, Hotel, Condo, & Commercial Demand	Resort at Squaw Creek Phase 2 Potable Demand	Existing Demand	New Single Family Demand	Golf Course Irrigation (after Phase 2)	Snowmaking (after Phase 2)			SVPSD	SVMWC	Total	
January	26	21	5	3	4	6	1	0	21	23	110	1	4	5	105
February	28	22	6	4	4	6	1	0	19	16	105	1	3	5	100
March	27	24	5	4	4	7	1	0	0	0	72	2	4	6	66
April	22	18	3	3	2	6	1	0	0	0	54	2	4	6	48
May	29	17	3	2	3	10	1	6	0	0	71	3	4	7	64
June	45	20	5	3	4	16	1	28	0	0	121	4	3	7	114
July	58	26	10	4	5	20	2	46	0	0	170	3	3	7	163
August	57	27	9	4	5	20	1	36	0	0	160	3	3	6	154
September	44	19	7	3	4	18	1	23	0	0	120	2	3	6	114
October	26	16	5	2	3	10	1	6	1	1	70	2	3	5	65
November	15	12	3	1	2	5	0	0	27	19	85	1	3	4	81
December	24	19	4	3	3	6	1	0	27	30	117	1	4	5	112
TOTALS	**403**	**240**	**64**	**35**	**43**	**130**	**10**	**145**	**94**	**89**	**1,254**	**26**	**42**	**68**	**1,186**

Notes:

General : - All values from Table 2 of Farr West June 2015.

- All values rounded to nearest whole number, totals may reflect the effects of rounding.

1 : SVPSD demands include Village at Squaw Valley demand estimate, current demands, non-project single family residential and commercial/multifamily demands, and the Resort at Squaw Creek Phase 2 potable water demands.

2 : SVMWC cumulative demands include current demand and new single family residential demands.

3 : RSC non-potable demands at 2040 assumed to be equivalent to the existing Development Agreement with SVPSD.

4 : Resort snow making volume and seasonal distribution supplied from the Olympic Valley Aquifer in 2040 assumed to be the same as recent historical averages plus a growth factor of 10 percent.

5 : 2000 to 2014 average production reported by SVPSD and SVMWC.

6 : Olympic Valley Groundwater Basin demand calculated by subtracting Total Average Horizontal Well Production from Total Demand column.

Table 2. Well Information

Well ID[1]	Existing, New, or Replacement	Well Type	Operator	Maximum Saturated Thickness[2] (feet)
SVPSD-1RR	Proposed Replacement	Municipal	SVPSD	153
SVPSD-2R	Existing	Municipal	SVPSD	78
SVPSD-3	Existing	Municipal	SVPSD	128
SVPSD-5R	Existing	Municipal	SVPSD	131
New-07/11	Proposed New	Municipal	SVPSD	98
New-09/14	Proposed New	Municipal	SVPSD	109
New-10/12	Proposed New	Municipal	SVPSD	114
New-14/08	Proposed New	Municipal	SVPSD	125
New-15/07	Proposed New	Municipal	SVPSD	114
New-16/10	Proposed New	Municipal	SVPSD	136
New-23/12	Proposed New	Municipal	SVPSD	122
New-39/54	Proposed New	Municipal	SVPSD	133
New-45/53	Proposed New	Municipal	SVPSD	142
RSC-18-3R	Existing	Municipal	SVPSD	--
SVMWC -1	Existing	Municipal	SVMWC	142
SVMWC -2	Existing	Municipal	SVMWC	128
RSC-Perini	Proposed New	Irrigation / Snow Making	RSC	--
RSC-Fourth Fairway	Existing	Irrigation / Snow Making	RSC	--
RSC-18-1	Existing	Irrigation / Snow Making	RSC	--
RSC-18-2	Existing	Irrigation / Snow Making	RSC	--
SC-ChildrensNW	Existing	Snow Making	SVR	--
SC-ChildrensNE	Existing	Snow Making	SVR	--
SC-ChildrensSE	Existing	Snow Making	SVR	--
SC-Cushing	Existing	Snow Making	SVR	--

Notes:

1 : Well identification notes: SVPSD-1RR is the replacement for well SVPSD-1R.
New wells are given designations based on row and column location within the model.
SC- designation wells are owned and operated by Squaw Valley Resort.

2: Maximum saturated thickness is the maximum modeled groundwater elevation in the well

Des by: CT
Ckd by: MR

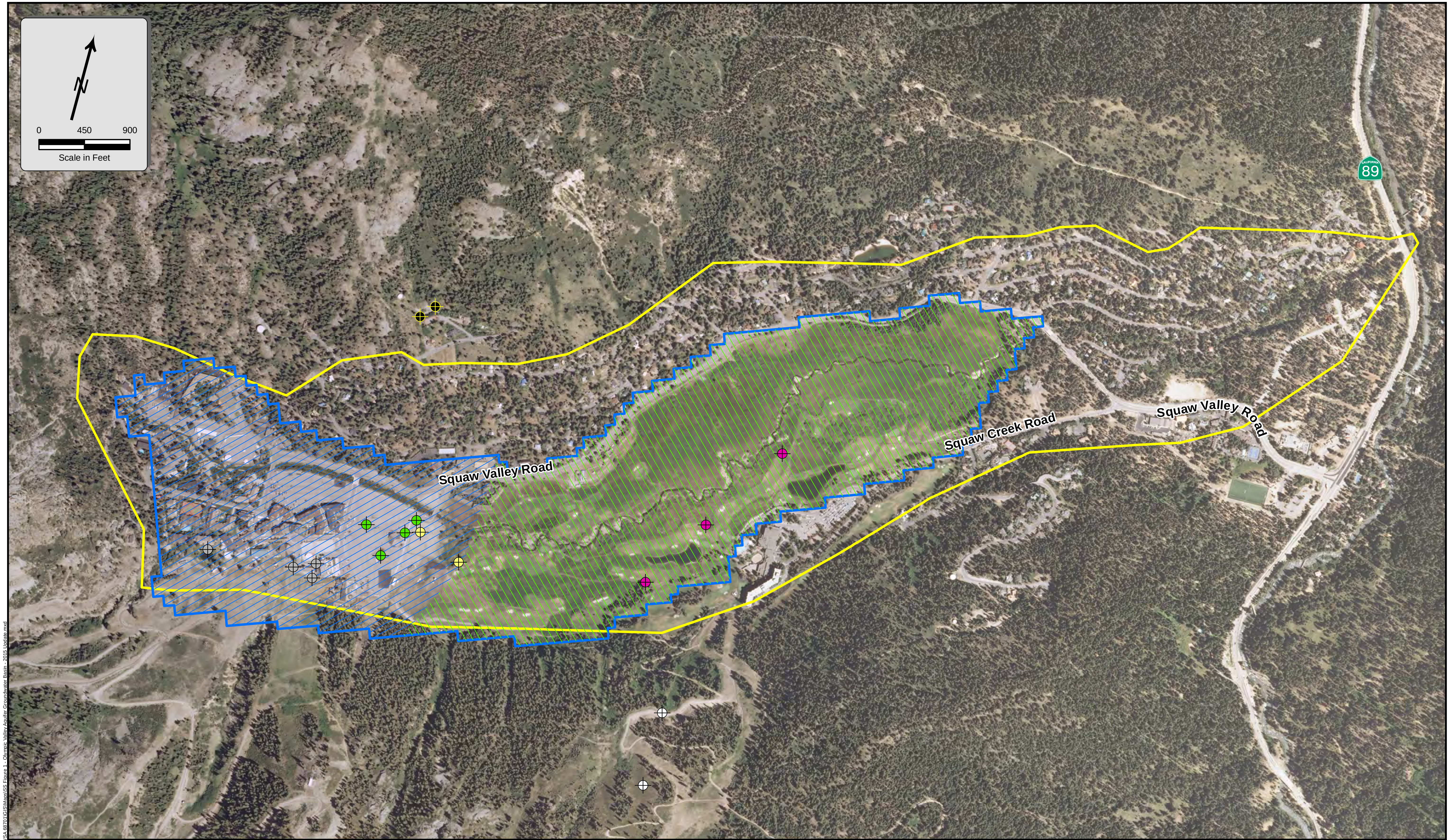
Table 3. Estimated Pumping by Well in 2040

All values in Acre-Feet

Month	SVPSD														SVMWC		RSC				SVR				Total Pumping
	SVPSD-1RR	SVPSD-2R	SVPSD-3	SVPSD-5R	New-07/11	New-09/14	New-10/12	New-14/08	New-15/07	New-16/10	New-23/12	New-39/54	New-45/53	RSC-18-3R	SVMWC -1	SVMWC -2	RSC-Perini	RSC-Fourth Fairway	RSC-18-1	RSC-18-2	SC-ChildrensNW	SC-ChildrensNE	SC-ChildrensSE	SC-Cushing	
January	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.3	1.4	2.1	12.8	7.7	0.0	0.0	5.5	5.5	5.5	6.2	**105**
February	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.2	2.0	1.4	12.1	7.3	0.0	0.0	3.8	3.8	3.8	4.3	**100**
March	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.4	2.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**66**
April	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	1.7	1.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**48**
May	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	2.7	4.1	2.9	3.8	2.6	0.0	0.0	0.0	0.0	0.0	0.0	**64**
June	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	4.0	6.6	6.6	16.4	10.9	0.3	0.6	0.0	0.0	0.0	0.0	**114**
July	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	4.7	6.9	11.3	17.2	11.4	5.8	11.36	0	0	0	0.00	**163**
August	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	5.4	7.2	11.3	17.3	11.5	2.5	5.0	0.0	0.0	0.0	0.0	**154**
September	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	4.0	5.9	9.4	14.0	9.3	0.0	0.0	0.0	0.0	0.0	0.0	**114**
October	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	2.7	2.9	4.3	3.6	2.5	0.0	0.0	0.3	0.3	0.3	0.3	**65**
November	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.0	0.9	1.2	15.4	10.3	0.3	0.6	4.3	4.3	4.3	6.0	**81**
December	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.0	1.6	1.8	16.2	10.8	0.0	0.0	6.7	6.7	6.7	9.5	**112**
Total	**55.1**	**55.1**	**55.1**	**55.1**	**55.1**	**55.1**	**55.1**	**55.1**	**55.1**	**55.1**	**55.1**	**55.1**	**55.1**	**43.2**	**43.9**	**54.4**	**128.9**	**84.2**	**8.9**	**17.5**	**20.7**	**20.7**	**20.7**	**26.4**	**1,186**

54.2635

FIGURES

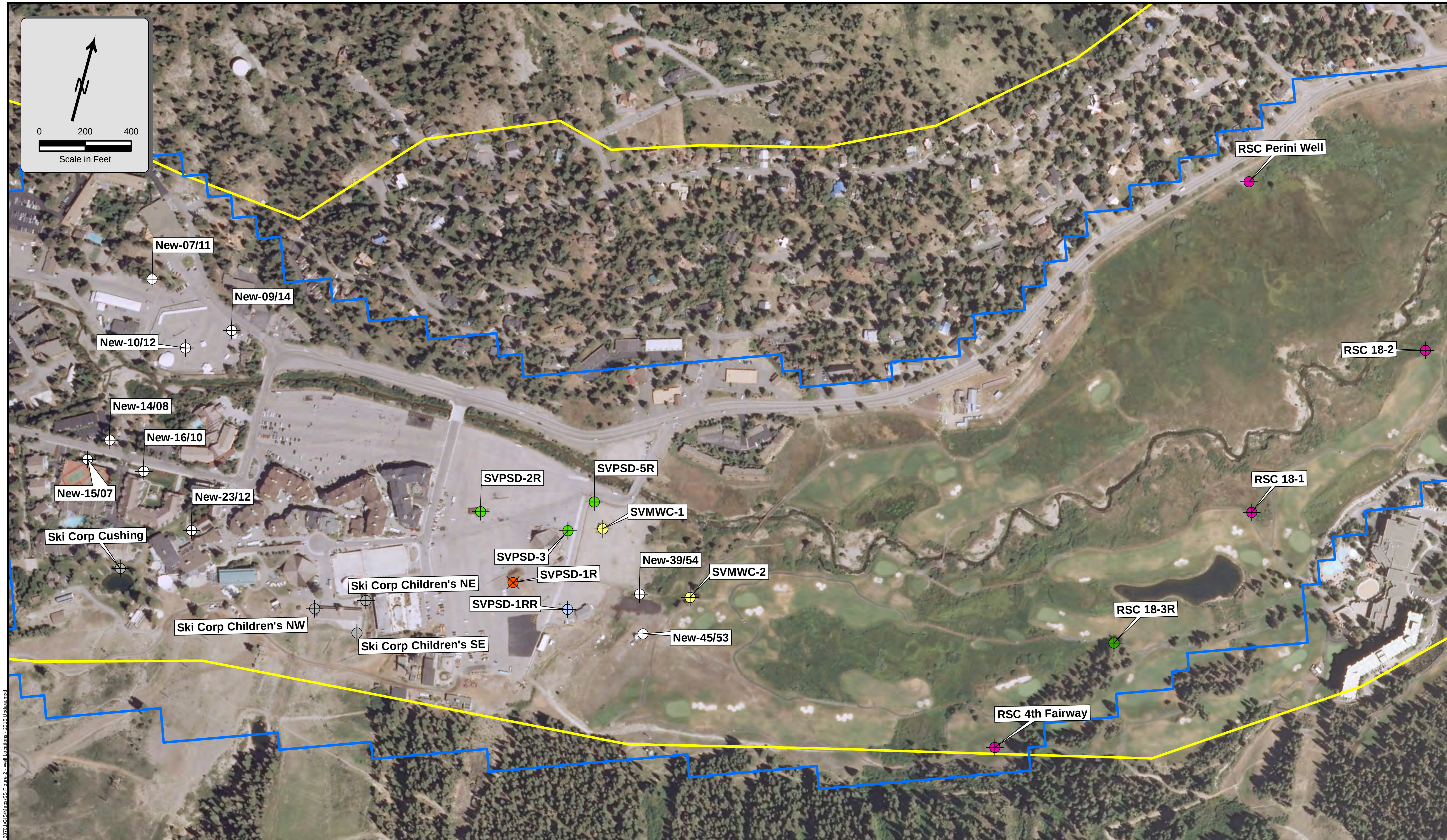


Active SVPSD Aquifer Well
SVPSD Horizontal
Active SVMWC Aquifer Well
SVMWC Horizontal
Squaw Valley Resort Well
Resort at Squaw Creek Well
DWR Designated Olympic Valley Groundwater Basin
Groundwater Management and Active SVPSD Model Area
Western Portion of Basin
Eastern Portion of Basin

July 2015

TODD GROUNDWATER

Figure 1
Olympic Valley Groundwater Basin and Existing Wells

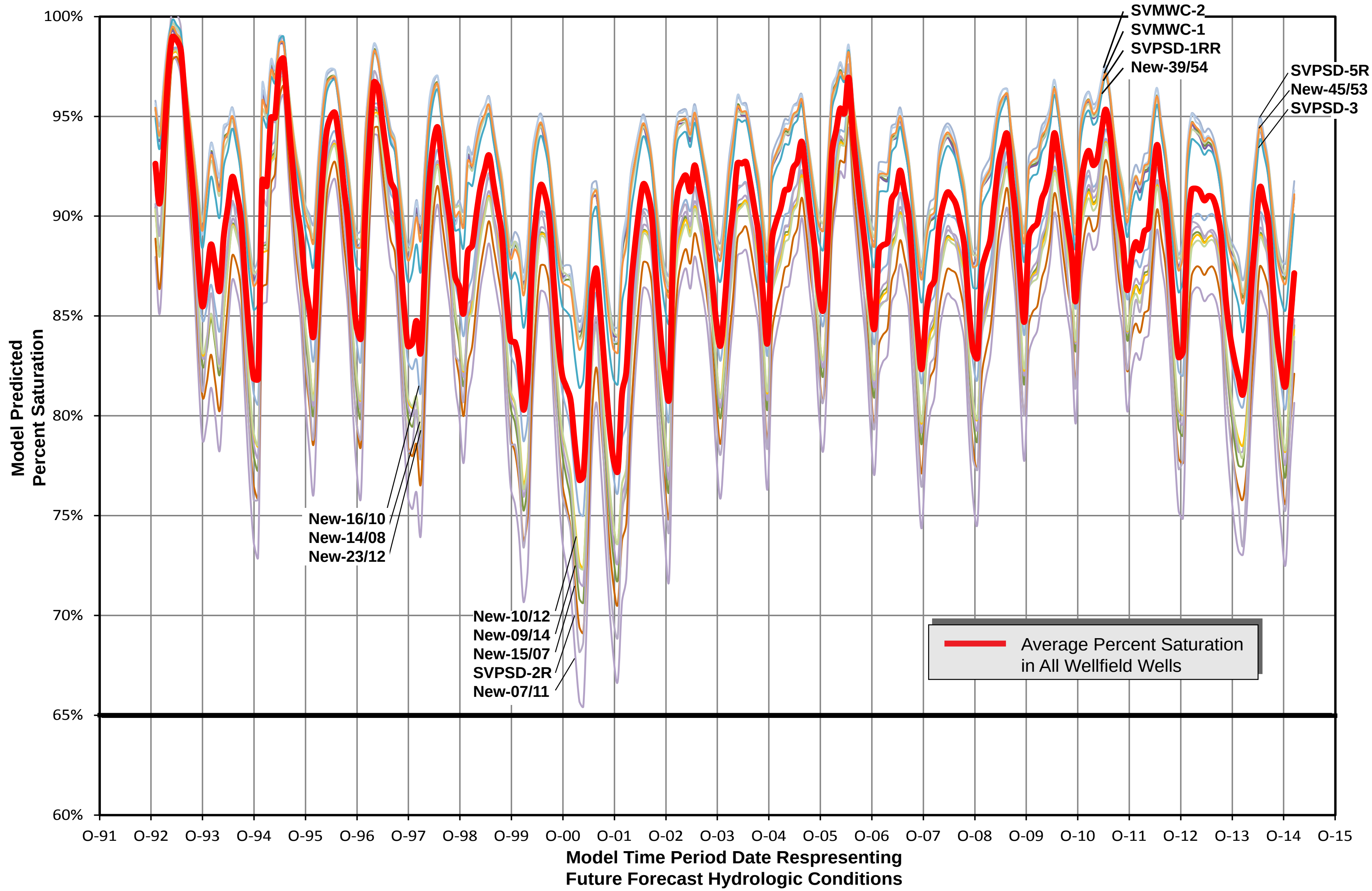


Proposed New Well
PSD Replacement Well
Existing PSD Well to Remain
Existing MWC Well to Remain
Squaw Valley Resort Well
Resort at Squaw Creek 18-3R
Resort at Squaw Creek Irrigation/Snowmaking Well
Well To Be Destroyed
Active Model Area
Olympic Valley Groundwater Basin

July 2015

TODD GROUNDWATER

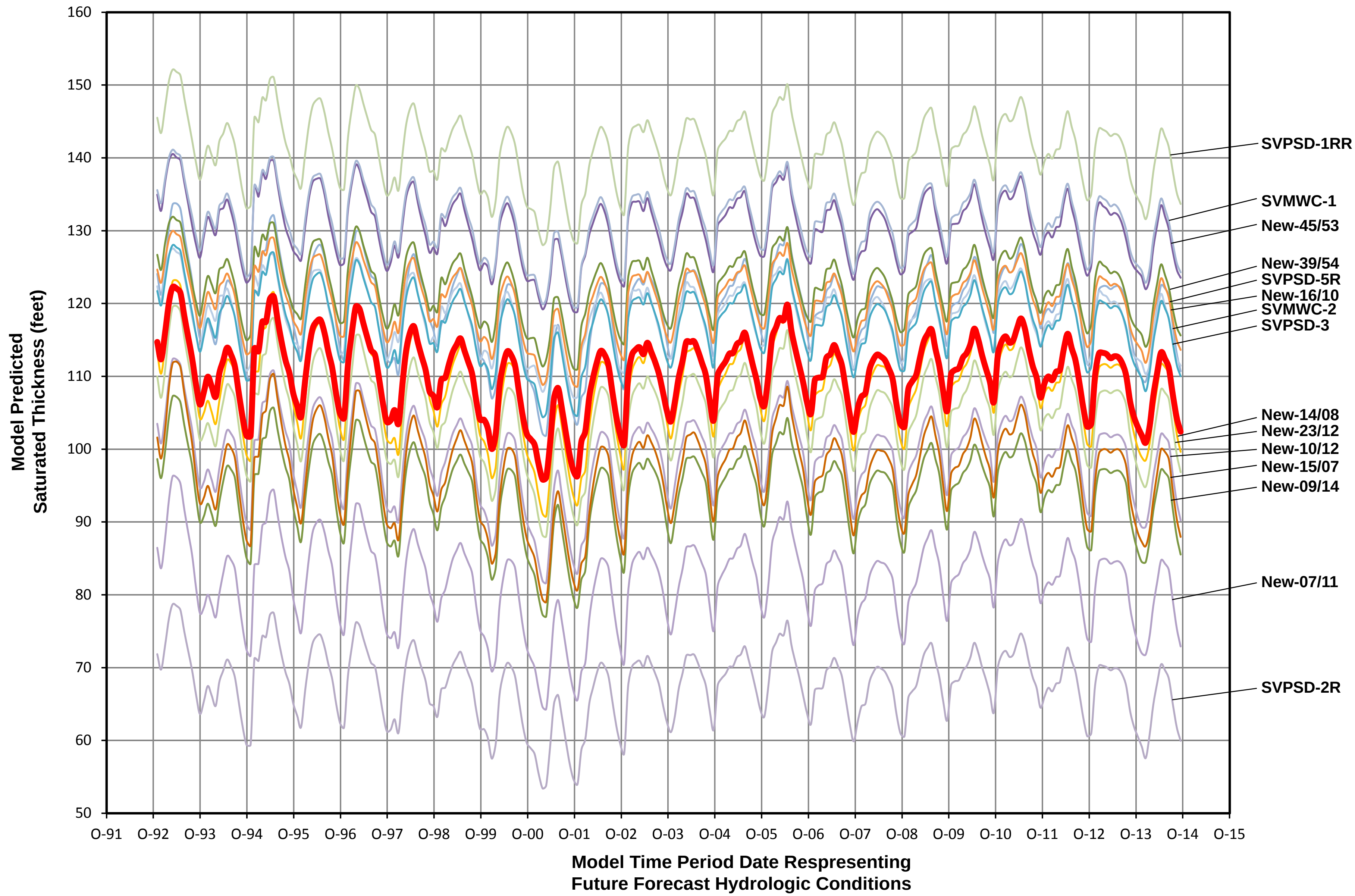
Figure 2
Existing and Modeled Well Sites
Village at Squaw Valley



July 2015

TODD GROUNDWATER

Figure 3
Percent Saturation All Wellfield Wells at 2040



July 2015

TODD GROUNDWATER

Figure 4
Saturated Thickness All Wellfield Wells at 2040